FRESHWATER GASTROPOD MOLLUSCA FROM ETHIOPIA

BRITISH MUSEUM
1 APR 1965
NATURAL HISTORY

BY

D. S. BROWN

Medical Research Council, c/o Section of Experimental Taxonomy,
Zoology Department, British Museum (Natural History)

Pp. 37–94 ; *Plates* 1–3 ; 47 *Text-figures*

BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
ZOOLOGY Vol. 12 No. 2
LONDON : 1965

THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in* 1949, *is issued in five series corresponding to the Departments of the Museum, and an Historical Series.*

Parts will appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

This paper is Vol. 12, *No.* 2 *of the Zoological series. The abbreviated titles of periodicals cited follow those of the World List of Scientific Periodicals.*

© Trustees of the British Museum (Natural History) 1965

TRUSTEES OF
THE BRITISH MUSEUM (NATURAL HISTORY)

Issued April, 1965 *Price Twenty-one Shillings*

FRESHWATER GASTROPOD MOLLUSCA FROM ETHIOPIA

By D. S. BROWN

SYNOPSIS

Gastropod molluscs were collected by the author between May and September 1962 from a variety of freshwater habitats in Ethiopia. Twenty-eight forms are represented in the collection of which a total of eleven have not been previously recorded from Ethiopia or have been recorded with doubt by previous authors. Two forms in each of the genera *Bulinus* and *Ancylus* appear to be new. It is considered that seven of the forms recorded from Ethiopia for the first time belong to the African component in the fauna, whereas only three are possibly of palaearctic origin. It is concluded that the wide distribution and diversity of some of the palaearctic forms justify the importance attached by Bacci (1951) to the palaearctic element in the molluscan fauna of the Ethiopian Plateau.

INTRODUCTION

A COLLECTION of freshwater molluscs was made by the author between May and September 1962 in the course of a survey to determine the distribution of potential intermediate hosts of human schistosomiasis in Ethiopia. Facilities provided by the Haile Selassie I, University College of Addis Ababa made it possible to visit many regions of Ethiopia, and a wide variety of aquatic habitats between sea level and 3,000 metres (10,000 ft.) were examined. An account of the Gastropoda collected during the survey is given in the present paper. Four new forms of Basommatophora are described and a total of ten do not appear to have been previously recorded from Ethiopa. Prosobranchia are relatively poorly represented in the collection ; no specimens of the genera *Cleopatra*, *Gabbia* or *Lanistes* were found. This can be only partly attributed to the high altitudes at which most of the work was carried out (over 1,500 m.), as the latter genus is present in Lake Tana (1,900 m.).

The arrangement of families and subfamilies is that employed by Wenz and Zilch[1]. As taxonomy within several families of African freshwater molluscs is in a state of flux at the level of the genus and below, a generic arrangement has been selected from existing accounts of the African fauna. Genera are used in the manner of Mandahl-Barth (1954), and *Bulinus* and *Biomphalaria* are classified in accordance with the species-group system proposed by this author (1957a, b). *Ferrissia* Walker is used in accordance with past practice although according to Dr. B. Hubendick (in litt.) true *Ferrissia* do not occur in Africa. Identifications have been based on shell and anatomy, and information is given that is relevant in comparison to existing descriptions which are amplified in some cases. Wherever possible, the forms in the present collection have been assigned to previously described taxa and where there are differences to the descriptions of previous authors these are discussed. Two forms of *Bulinus*, and one form of *Ancylus* are apparently new but have not been named as it is evident that revision is necessary

[1]Wenz, W. Handbuch der Palaeozoologie, Berlin. 6. Gastropoda Pt. 1 Prosobranchia 1938–1944. Pt. 2. Euthyneura (by A. Zilch) 1959–1960.

throughout these genera before the status of these Ethiopian forms can be properly established. One purpose of the present paper is to bring the material to the attention of malacologists who may undertake works of revision in the future.

In comparison to other parts of Africa a relatively large number of travellers have made collections of molluscs in Ethiopia. Bacci (1951) gives a comprehensive catalogue of records of Ethiopian Mollusca up to 1941 and proposes many cases of synonymy. Synonymies given in the present paper are primarily local and the references included represent either original locality records or nomenclatural variations. Works in which names have been cited without change are omitted.

Localities are defined in relation to towns or other landmarks which are all listed at the end of the paper with map references. In the text localities are grouped into provincial areas in order to make possible a rapid assessment of distribution by reference to Map 1 in which approximate provincial boundaries are shown. The routes followed during the survey are also indicated on the map. The majority of habitats in which molluscs were found were situated on the Ethiopian plateau between altitudes of approximately 1,800 m. (6,000 ft.) and 2,700 m. (9,000 ft.). A general account of the geography and climate of the country is given by Ayad (1956) ; the distribution and nature of aquatic habitats is described elsewhere (Brown, in preparation). The number of specimens obtained in each sample is shown between brackets, and an asterisk indicates that only empty shells were found.

The collection is deposited in the Section of Experimental Taxonomy, British Museum (Natural History). Specimens have also been deposited in the World Health Organisation Snail Identification Centre, Charlottenlund, Denmark. These collections are referred to in the text as (B.M.N.H.) and (W.H.O.) respectively.

It is a pleasure to record my thanks to Mr. J. MacFarlane and Dr. A. Tjønneland (Haile Selassie I University College, Addis Ababa) for their ready assistance. I am grateful to the Trustees of the British Museum (Natural History) for the provision of working facilities, and to Dr. C. A. Wright for accommodation in the Section of Experimental Taxonomy. Dr. G. Mandahl-Barth has been generous of his time, I am indebted to him for much stimulating discussion and the opportunity to examine the collection of the World Health Organisation Snail Identification Centre. Dr. J. Burch has kindly allowed me to quote some of his unpublished observations on the chromosomes of *Bulinus*. Thanks are due to Mr. D. Claugher and Miss J. Lines for the care they have devoted to the preparation of photographs and radulae.

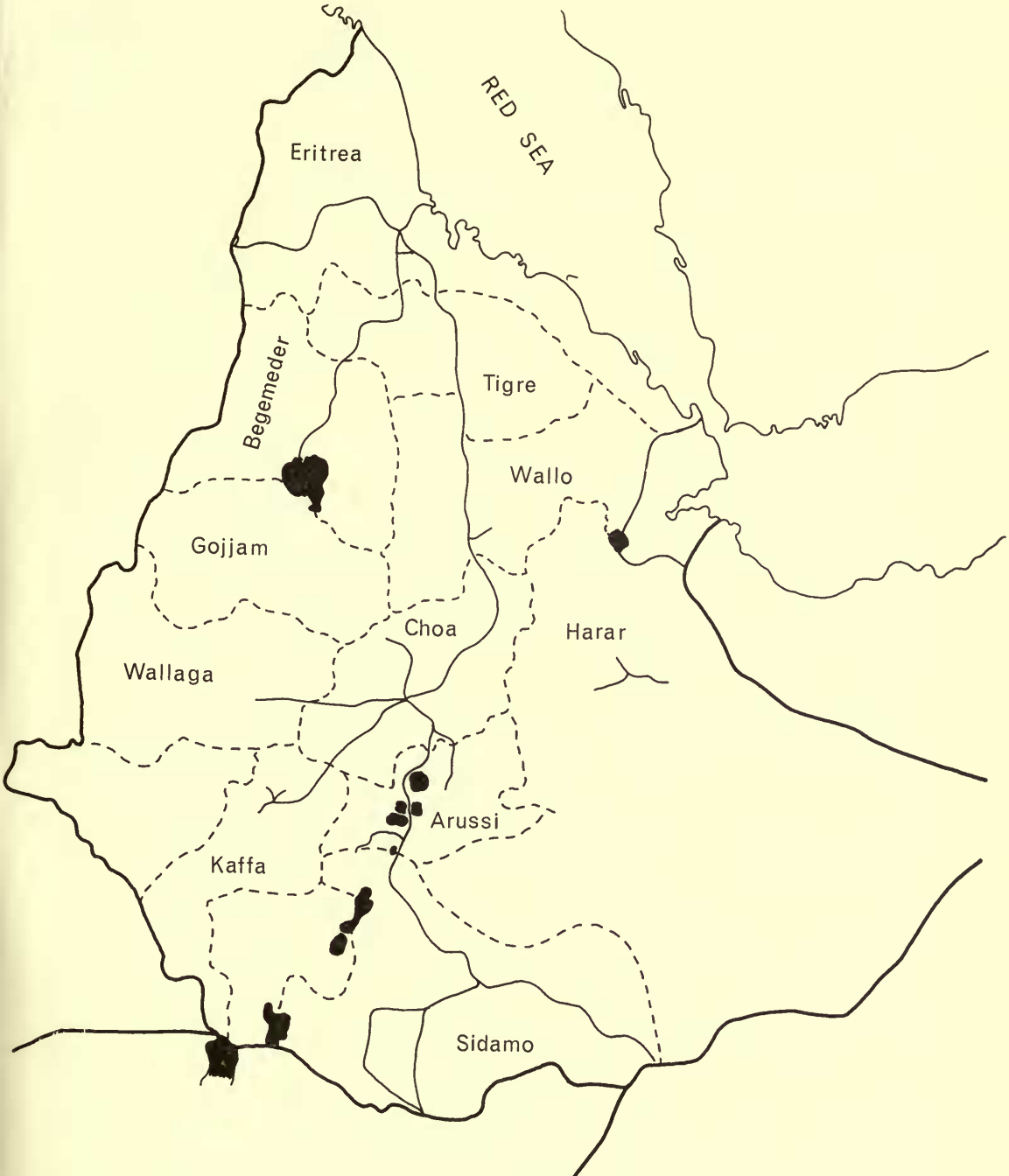
Family **VIVIPARIDAE**

BELLAMYA Jousseaume

Bellamya unicolor (Olivier)

Cyclostoma unicolor Olivier, 1804 : 39, pl. 31, fig. 9 ; *Paludina unicolor* Martens, 1866 & 1867 ; *Vivipara unicolor* ; Jickeli, 1874 ; *Viviparus unicolor ;* Thiele, 1933 ; Bacci, 1940 ; Piersanti, 1940 ; *Viviparus* (*Bellamya*) *unicolor ;* Bacci, 1943 ; *Bellamya unicolor unicolor ;* Bacci, 1951 ; *Bellamya unicolor ;* Mandahl-Barth in Ayad, 1956.

Paludina abyssinica Martens, 1866 : 97, pl. 3, fig. 7, & 1867 ; *Vivipara abyssinica ;* Jickeli



MAP 1. Ethiopia. Boundaries of Provinces indicated by broken lines ; routes followed in making the present collection indicated by solid lines.

1874 ; *Viviparus unicolor abyssinicus ;* Piersanti, 1940 ; *Bellamya unicolor abyssinica;* Bacci, 1951.

Localities. Arussi : 5 km. approx. S. of Adamitullo (between Lake Zwai and Bulbulla River) (8)*; Lake Abyata, east shore (1)*. Begemeder : Lake Tana at Gorgora (130).

Shell

Lake Tana (pl. 1, 1 & 2). Although the apices are eroded in the larger specimens many shells are moderately short spired having the length of the spire approximately equal to that of the aperture. The peripheral angulation is acute in young specimens, but is indistinct in large shells. The shoulder angulation is scarcely visible in both big and little specimens. Microsculpture on the apical whorls consists of coarse spiral ridges, which subsequently become finer and wavy and are crossed by irregular transverse growth ridges. In a representative shell there are 5 spiral ridges at the beginning of the second whorl, and 16 at the beginning of the third whorl.

The outer lip of the aperture is thickened and coloured black-brown in many of the larger shells, in others this dark band is present a short distance from the outer lip and further back there may be one or two more according to the size of the shell. All the bands are usually situated in the ultimate whorl. Similar bands have been observed in *Bellamya* from other parts of Africa and it is likely that growth takes place in several stages in such populations.

There appears to be sexual dimorphism in size : 19 of 23 specimens of more than 20 mm. length are female ; 3 of 11 specimens between 15 and 20 mm. are female.

Largest shell : L = 27·7 mm.; ML = 13·7 mm.; W = 19·4 mm.

Arussi : near Lake Zwai (pl. 1, 3). All the shells are distinguishable from Lake Tana specimens of the same size by the more acute peripheral and shoulder angulations, and the relatively sharp apices. Microsculpture on the lower whorls is similar to that of the Lake Tana specimens, but the apical whorls are smooth, probably as a result of weathering. Sub-fossil in a lacustrine deposit.

Largest shell : L = 21·5 mm. ; ML = 10·3 mm. ; W = 16·5 mm. ; 6¼ whorls.

Anatomy (Text-figs. 1–5)

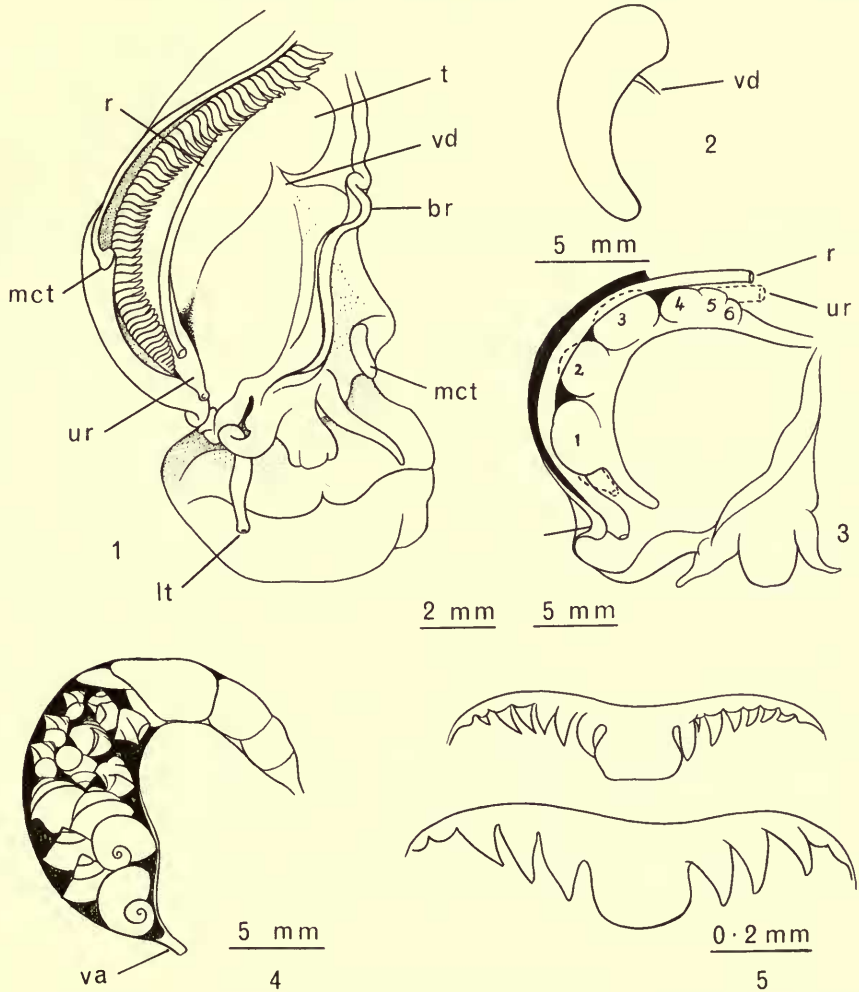
The male genital system (Text-figs. 1 and 2) closely resembles that of *Viviparus* (= *Bellamya*) *unicolor* as described by Rohrbach (1937). A crescentic testis with a narrower anterior end is situated on the right side of the roof of the mantle cavity close to the right side of the rectum. The ureter is attached to the adjoining edges of the testis and the rectum. After emerging from near the posterior end of the testis, the vas deferens passes beneath connective tissue across the floor of the mantle cavity to the left side, where it widens and runs forward beneath a branchial fold as the prostate " gland ". After becoming narrower the vas deferens passes into the right tentacle, at the tip of which is the male aperture.

The uterus occupies a similar position to the testis in the male, with the vagina projecting as a short tube from the floor of the mantle cavity. Great variation was observed in the number and the size of the shelled embryos present in large females

of approximately the same size. Occasionally only a single young snail was present' but more frequently a few large ones were arranged in a single row (Text-fig. 3). In some specimens many young snails were arranged in two or three rows ; the greatest number of young observed in such a uterus being 28 (Text-fig. 4).

Radula (Text-fig. 5)

The length of the median cusp of the central tooth is more than half the breadth of the cusp. There are 3–7 lateral cusps on each side of the median cusp, and in addition the upper lateral edges of the central tooth may bear a few notches.



Figs. 1–5. *Bellamya unicolor* from Lake Tana. Fig. 1. Mantle cavity of male exposed by turning mantle to right. Fig. 2. Testis. Fig. 3. Female of shell length 27·2 mm., left side of mantle removed and the remainder turned to the right exposing uterus, embryos numbered 1–6. Fig. 4. Uterus of female 21·5 mm. shell length with wall removed to expose young snails and embryos. Fig. 5. Cusp bearing parts of two representative central teeth from radula.

Remarks. In the shape of the shell, and the presence of a short median cusp on the central tooth of the radula, these specimens conform to the *Bellamya unicolor* group described in Uganda by Mandahl-Barth (1954). If the apices were not eroded some of the larger shells from Lake Tana (pl. 1, 1) would approach the elongated shape of *B. abyssinicus* (Martens) in which the spire is approximately equal to 1½ times the aperture length. In addition to the original specimens from South Ethiopia, von Martens' species appears to be known only from Lake Tana (Martens, 1867 and Piersanti, 1940), but the range of variation in the present sample from this lake indicates that the form is not separable from *B. unicolor*.

As appears to be the case in other parts of Africa, *Bellamya* has only been found in or near large bodies of water in Ethiopia. The sub-fossil shells from the vicinity of Lake Zwai probably represent a population that existed when the floor of this part of the Rift Valley was more extensively covered by fresh water than it is at the present time (Mohr, 1961) ; there is a close resemblance between these shells and those described by Bacci (1940) from a nearby locality. Thiele (1933) records living *B. unicolor* from near Lake Zwai, and it is possible that living populations remain to be discovered in some of the Rift Valley Lakes.

Rohrbach (1937) found specific anatomical differences between *B. unicolor* from the Nile at Cairo, and *B. capillatus* from N. Rhodesia. The male genital system of the Lake Tana specimens resembles that of the specimens from the Nile described by Rohrbach, but only a few of the Lake Tana females have a large number of embryos arranged in two or more rows as described by this author, who found up to 86 relatively small embryos in *B. unicolor* in contrast to 25–40 larger ones in *B. capillatus*. Though the number of embryos in the Lake Tana females is generally even less than that found in *B. capillatus* by Rohrbach, the arrangement in several rows when a large number is present, considered in conjunction with the anatomy of the male system, is evidence that this population is related to *B. unicolor* of the Nile. The small number of embryos present in the uterus may represent an adaptation to local conditions and it is probable that the anatomical and ecological distinctions between *B. unicolor* and *B. capillatus* will be found to be less clear than was thought by Rohrbach.

Distribution. *Bellamya* is known in Ethiopia only from Lake Tana, near Lake Zwai, Lake Abyata (Bacci, 1943), and an unspecified locality in the southern part of the country (Martens). Many species which are probably conspecific with *B. unicolor* have been described in other parts of Africa ; the range of the genus extends down the basin of the River Nile to the Mediterranean and as far west as Senegal, the southern limit of distribution appears to be in Zululand.

Family **AMPULLARIIDAE**

PILA Röding

Pila speciosa (Philippi)

Ampullaria speciosa Philippi, 1849 : 18, and in Martin & Chemnitz, 1851 : pl. 11, fig. 2.

Locality. Sidamo : 40 km. approx. W. of Dolo on Filtu road, near Ganale River, (1).*

Shell

The dimensions of the single empty shell are : L = 50 mm. ; ML = 38 mm. ; W = 45·5 mm.

Remarks. This species is known from Somalia and the Kenya-Somalia border (Bacci, 1951 and Pain, 1961), and it is not surprising that its range extends for at least a short distance up the Ganale River into Ethiopia.

Family **VALVATIDAE**

VALVATA Müller

Valvata sp.

Valvata nilotica Jickeli, 1874 : 223, pl. 7, fig. 29 ; Bacci, 1940 ; *Valvata nilotica nilotica ;* Bacci, 1951 ; *Valvata nilotica* var. *scioana ;* Pollonera, 1888 : 62 ; *Valvata nilotica scioana ;* Bacci, 1940.
Valvata sp. Mandahl-Barth in Ayad, 1956.

Localities. Choa : 72 km. N. of Addis Ababa boundary of Debra Markos road, (17) ; 0·5 km. S. of Debra Berhan, (50) ; Lake Wonji, (10).

Shell (pl. 1, 4–9)

Two specimens are illustrated (pl. 1, 6 and 8) which represent the extremes of variation in the rate of descent of the whorl within a single sample (72 km. N. of Addis Ababa on Debra Markos road). In the Debra Berhan sample (pl. 1, 4 and 5) the range of the ratio L/W is 0·82–1·00 (10 shells). The umbilicus of shells from Lake Wonji (pl. 1, 7 and 9) is distinctly smaller than in the other samples. Fine transverse ribs are more or less regularly spaced on the apical whorls, where there is also a fine spiral sculpture.

Largest shell : L = 4·8 mm. ; ML = 3·0 mm. ; W = 6·0 mm. ; 3¾ whorls.

Remarks. If *Valvata* of the Egyptian Nile are regarded as distinct from European species, it is possible that *V. saulcyi* Bourguignat 1853 should take precedence over *V. nilotica* Jickeli. As a detailed comparison between specimens of *Valvata* from Ethiopia, Egypt and Europe has not yet been made, a specific identification of the specimens in the present collection is impossible.

Variety *scioana* was described on the basis of three specimens from near Debra Berhan, in which the spire was considered to be less depressed, and the umbilicus more restricted, than in Jickeli's illustration of *V. nilotica.* Bacci (1940) observed that the majority of fossil specimens of *Valvata* from the vicinity of Lake Zwai were similar to var. *scioana,* and most of the shells in the present collection resemble this form in possessing a relatively rapidly descending whorl. The shells from Debra Berhan have even higher spires than the shells of *scioana* described by Pollonera : the mean ratio L/W is 0·90 (10 shells), compared to ratios of 0·66 (var. *scioana*) and 0·63 (*V. nilotica*) calculated from the dimensions given by Pollonera and Jickeli respectively. Restriction of the umbilicus does not appear to be necessarily

associated with increase in the rate of descent of the whorl as suggested by Pollonera. Both low-spired and the high-spired shells from the north of Addis Ababa (pl. 1, 6 and 8) have a large umbilicus, but it is restricted in all the specimens from Lake Wonji.

Valvata revoili Bourguignat, 1889, is listed with reservation by Bacci (1951), and is considered to be a terrestrial species by Dr. G. Mandahl-Barth (pers. comm.).

Distribution. *Valvata sp.* appears to have a wide range at moderately high altitudes in Ethiopia, occurring in both still and slow-flowing waters ; it is recorded by Ayad from south of Addis Ababa (Akaki) and from the Blue Nile near Lake Tana. This genus reaches the southern limit of its distribution in North Africa ; several species have been described from the lower course of the Nile and *V. tilhoi* Germain was described from the vicinity of Lake Chad.

Family **THIARIDAE**

MELANOIDES Olivier

Melanoides tuberculata (Müller)

Nerita tuberculata Müller, 1774 : 191 ; *Melania tuberculata ;* Blanford, 1870 ; Morelet, 1872 ; Jickeli, 1874 ; Bourguignat, 1872, & 1833, & 1885 ; Pollonera, 1898 ; De Rochebrune & Germain, 1904 ; Neuville & Anthony, 1908 ; Kobelt, 1910 ; *Melania* (*Melanoides*) *tuberculata ;* Thiele, 1933 ; Bacci, 1940 & 1941 ; *Melanoides* (*Thiara*) *tuberculata ;* Piersanti, 1940, & 1941 ; *Melanoides tuberculata ;* Ayad, 1956 ; Verdcourt, 1960 ; *Melania tuberculata* var. *costata* Bourguignat, 1864 : pl. 15, figs. 3 & 10 ; Pollonera, 1898.
Melania dembea Reeve, 1860 : pl. 23, fig. 161.
Melania curvicosta Pantanelli, 1897 : 204.

Localities. Arussi : 5 km. approx. S. of Adamitullo (between Lake Zwai and Bulbulla river), (6) *; Lake Zwai, N.W. shore, (1) ; River Awash, S. of Nazareth, (52). Eritrea : 20 km. approx. W. of Asmara on Massawa road. Sidamo : Lake Margherita, E. shore, (13).* Wallo : Lake Haik, (2).

Shell

Spiral ribs are present on the lowermost part of the shell, and tubercles are generally better developed than in the forms described by Mandahl-Barth (1954). In specimens from the River Awash, south of Nazareth, conspicuous transverse ribs are formed by the fusion of the large tubercles.

Remarks. Specimens from near Saati (between Asmara and Massawa), with thick transverse ribs, were identified by Pollonera (1898) as var. *costata* Bourguignat. The specimens described above from the River Awash also resemble this form.

No specimens were found in Lake Tana, the type locality of *Melania dembea* Reeve, a form with moderately well developed transverse ribs that does not appear to differ significantly from *M. tuberculata.*

Distribution. *M. tuberculata* is widely distributed in Ethiopia from near sea-level to an altitude of about 6,000 feet (Lake Tana) on the plateau. Its range includes most of Africa, excluding the Niger and Congo basins, and extends into the Arabian Peninsula and Asia.

Family **PHYSIDAE**

PHYSA Draparnaud

Physa sp.

LOCALITY. Choa : River Awash, below Koka Dam, (50).

Shell (pl. 2, 1)

The shell is moderately shiny ; many specimens have a light-coloured band a short distance from the outer lip. Fine transverse corrugations extend across the whorl, and are interspersed with short ones which are arranged in spiral rows on some parts of the surface.

Anatomy (Text-figs. 6–9)

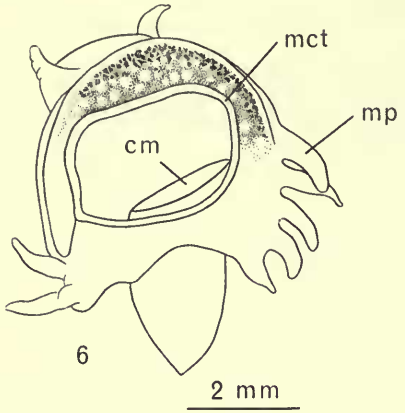
The distribution of pigment in the mantle (Text-fig. 6) forms light spots on a grey background, with small dark spots that are most numerous near the mantle edge. From beneath the anterior mantle edge projects a narrow flap that continues around the visceral hump with long finger-like projections from the posterior part.

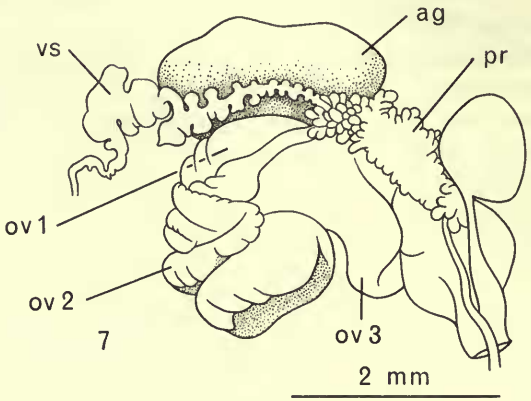
The ovotestis consists of many acini scattered in the digestive gland. There are numerous blunt projections from the seminal vesicle region of the hermaphrodite duct (Text-fig. 7). Three regions may be distinguished in the female duct (Duncan, 1958) ; the proximal oviduct 1 is straight and narrow, and this leads to the junction between a highly convoluted oviduct 2 and the wide oviduct 3 which terminates in a short vagina. After leaving the junction with the hermaphrodite duct the vas deferens receives numerous prostatic diverticula, each of which is branched several times. A blunt papilla projects into the lumen of the preputium from the junction between the penis sheath and the preputium (Text-fig. 8) ; the tip of the penis usually reaches as far as the tip of the papilla, but the penis is considerably shorter in a few specimens. A preputial gland may be seen as a lightly pigmented oval area on the outer wall of the preputium, on the opposite side to the insertion of the retractor muscle. Internally the gland bulges into the lumen of the preputium, filling it almost completely. The junction between the male and female systems (Text-fig. 9) is similar to that described by Duncan (loc. cit.) for *Physa fontinalis*. The vas deferens (vd) arises from the hermaphrodite duct (hd) before this duct enters the albumen gland, but the junction between the hermaphrodite duct, oviduct 1, and the lumen of the albumen gland is surrounded by albumen gland tissue. Two fertilisation pockets project from the base of oviduct 1.

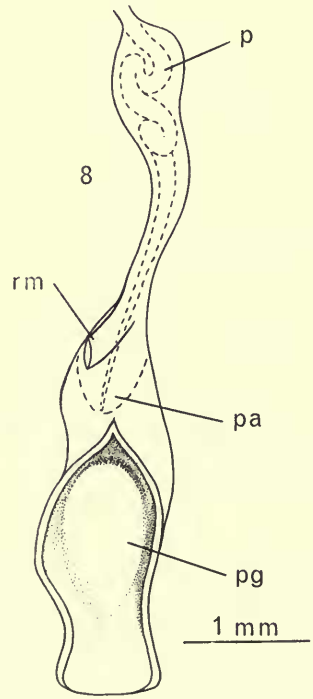
REMARKS. In both shell and anatomy the Ethiopian *Physa* resemble the southern European species *P. acuta* Draparnaud as described by Slugocka (1913) ; similar *Physa* have been examined (W.H.O.) from Kenya and Southern Rhodesia. These shells also closely resemble *P. borbonica* Férussac originally described from Mauritius. The elucidation of the relationships of the *Physa* in East Africa is a matter for future investigation.

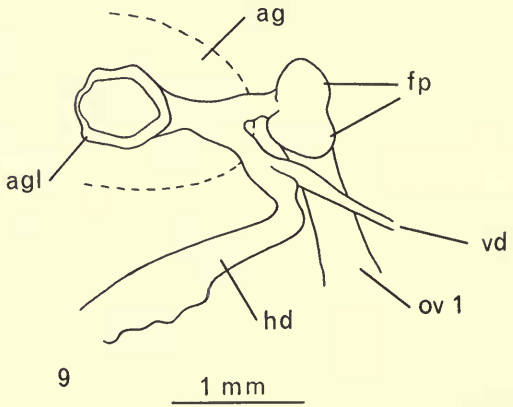
DISTRIBUTION. *Physa* has not been reported previously from Ethiopia, but its occurrence might be expected as the genus is present in Egypt and Kenya. Cases of introduction of species of *Physa* in other parts of the world are known, and as *Physa sp.* was abundant in the single locality where it was found, it is likely that the

snail has been recently established in Ethiopia and will become more widely distributed in the future.









FIGS. 6–9. *Physa* sp. from below Koka Dam. Fig. 6. Dorsal view of whole animal with visceral hump removed, pigmentation shown on anterior part of mantle only. Fig. 7. Distal genital organs. Fig. 8. Copulatory organ, penis and papilla shown by dotted lines and wall of preputium opened to show preputial gland. Fig. 9. Junction of male and female systems, position of albumen gland shown by dotted lines.

Family **LYMNAEIDAE**
LYMNAEA Lamarck
Lymnaea truncatula (Müller)

Buccinum truncatulum Müller, 1774 : 130 ; *Limnaea truncatula? ;* Jickeli, 1874 ; Bourguignat, 1883 ; Pollonera, 1898 ; Germain, 1904 ; Connolly, 1928 ; *Lymnaea truncatula ;* Wright & Brown, 1962 ; *Galba truncatula ;* Piersanti, 1941.
Limnaea peregra? ; Jickeli, 1874.

Localities. Arussi : 50 km. W. of Shashamanne on Soddu road, (4). Begemeder : 19–97 km. N. of Gondar on Asmara road, 6 samples, (100). Eritrea : 19 km. E. of Teramni on Decamere road, (1) ; 66 and 101 km. S. of Asmara on Addis Ababa road, (6) ; River Toquor near Mekerka, (1). Kaffa : 5 and 9 km. W. of Kombi, (2). Choa : 2–150 km. N. of Addis Ababa boundary on Debra Markos road, 5 samples, (15) ; Lake Wonji, (2) ; 29 km. W. of Addis Ababa on Lekemti road, (4). Wollo : Kombolchia village on Dessie road, (2) ; 8 km. N. of Dessie on Asmara road, (5). Harar : 71 km. on Carsa road from junction with Dire Dawa–Harar road, (20).

Shell (pl. 2,5)

There is a close resemblance to specimens from near Debra Markos described by Wright & Brown (1962).

Largest shell : L = 11·7 mm. ; ML = 6·2 mm ; W =6·0 mm. Several specimens in this sample are conspicuously malleated (pl. 2, 5).

Radula

In the 12 radulae examined the endocones of the first few lateral teeth are relatively smaller than in the lateral tooth illustrated by Wright & Brown (loc. cit.). In some lateral teeth the meso- and ectocones are elongated giving the teeth a bicuspid appearance which resembles the condition in *L. truncatula* from Aden (Wright, 1963b), though the cusps are shorter in the Ethiopian specimens.

Remarks. The specimen of *L. peregra?* from the River Toquor near Mekerka illustrated by Jickeli (1874) closely resembles *L. truncatula* which was collected from the same locality during the recent expedition. However it is possible that living populations of European *Lymnaea* other than *L. truncatula* will be discovered in Ethiopia.

Distribution. The majority of previous records of *L. truncatula* are from northern Ethiopia, but it has also been found in a sub-fossil condition as far south as the Nargi Plain, near Lake Stephanie (Piersanti, 1941). The present records suggest that this species is widely distributed at moderately high altitudes on both sides of the Rift Valley, and living populations may also occur at lower altitudes as is the case in Tanganyika (Mandahl-Barth, pers. comm.).

Lymnaea natalensis (Krauss)

Limnaeus natalensis Krauss, 1848 : 15, pl. 5, fig. 15 : Blanford, 1870 ; *Lymnaea natalensis ;* Mandahl-Barth in Ayad, 1956 ; Wright & Brown, 1962.
Limnaeus natalensis exsertus Martens, 1866 : 101, pl. 3, figs. 8 & 9 ; *Limnaea natalensis* var. *exserta ;* Jickeli, 1874 ; *Limnaea exserta ;* Bourguignat, 1883 ; Pollonera, 1898.

Limnaea orophila Morelet, 1868 : 87, pl. 7, fig. 4 ; *Limnaea natalensis* var. *orophila* Jickeli, 1874.
Limnaea caillaudi Bourguignat, 1883 : 89, pl. 10, figs. 100 & 101 ; Pollonera, 1898 ; Connolly, 1928 ; *Radix caillaudi ;* Bacci 1941.
Limnaea acroxa Bourguignat, 1883 : 90, pl. 10, fig. 94.
Limnaea alexandrina Bourguignat, 1883 : 92, pl. 10, figs. 95 & 96 ; De Rochebrune & Germain, 1904 ; *Limnaea exserta* var. *alexandrina ;* Pollonera, 1898.
Limnaea raffrayi Bourguignat, 1883 : 93, pl. 10, figs. 97 & 98 ; Pollonera, 1898.
Limnaea aethiopica Bourguignat, 1883 : 94, pl. 10, figs. 92 & 93 ; Neuville & Anthony, 1908.
Limnaea africana " Rüppell " Bourguignat, 1883 : 95, pl. 10, fig. 99 ; Neuville & Anthony, 1908.
Limnaea graveiri Bourguignat, 1885 : 23, fig. 6.
Limnaea soleilleti Bourguignat, 1885 : 24, fig. 7.
? *Radix pereger ;* Piersanti, 1940.

Localities. Arussi : Lake Zwai, (11). Begemeder : 308 km. S. of Asmara on Gondar road, (15) ; Lake Tana at Gorgora, (6). Choa : Tributaries of the River Awash at Akaki and Dukem, (12) ; River Awash below Koka Dam, (12); 22–318 km. N. of Addis Ababa on Asmara road, 4 samples, (75) ; 21 km. E. of Wolisso, (10). Eritrea : 22–83 km. S. of Asmara on Gondar road, 4 samples, (90) ; 15 km. approx. N.W. of Asmara on Cheren road, 2 samples, (30) ; River Toquor near Mekerka, (60) ; 3 km. E. of Teramni on Decamere road, (5) ; 66 and 101 km. S. of Asmara on Addis Ababa road, (30). Harar : 10 km. W. of Harar on Dire Dawa road, (30) ; Lake Aramyia, (50) ; 43 km. on Carsa road from junction with Dire Dawa–Harar road, (30). Kaffa : 26 km. W. of Sokuru, (6) ; 9 and 22 km. W. of Assendabo, (60) ; 13 and 14 km. W. of Jimma on Bonga road, (18) ; 34 and 38 km. N. of Jimma on Agarro road, (27) ; 4 km. E. of Jimma on Addis Ababa road, (24). Sidamo : Lake Margherita, (40) ; Neghelli, (40). Tigre : 0·5 km. W. of Adowa on Gondar road, (4) ; 222 km. S. of Asmara on Addis Ababa road, (5). Wollo : 26 km. S. and 0·5 km. N. of Kombolchia on Dessie road, (20) ; 1 km. W. of Batei, (23) ; 1 and 30 km. N. of Dessie on Asmara road, (80).

Shell (pl. 1, 10 and 11)

Five of the largest shells from all the samples were measured ; the extreme values of the mean ratio L/ML are 1·27 and 1·51, and the values for individual shells range between 1·23 and 1·54.

Largest shell (northern Choa) : L = 24·7 mm. ; ML = 18·7 mm. ; W = 14·5 mm.

Although there is a wide variation in the shape of the spire and the aperture through the whole series of samples, many of the samples have a distinctive appearance. A relatively high proportion of long-spired samples were obtained from Kaffa and Harar Provinces. Spiral rows of corrugations and depressions are present in many samples, but the extent to which this microsculpture covers each shell varies, and it may be confined to the apex only. Microsculpture is lacking from many of the shells collected in Harar, and in none of them is it well developed.

Anatomy

Both the intensity and arrangement of mantle pigmentation is very variable. A few unpigmented spots may be surrounded by a dense dark background, or at the other extreme pigmentation may be reduced to a fine network.

The genital system resembles that of specimens from Gojjam Province, Wright & Brown (1962). Some specimens from every sample were dissected, and in all of them the distal part of the prostate gland was swollen and a large internal fold was present.

Radula

The endocones and mesocones of the lateral teeth of several radulae (14 radulae from 3 samples examined) are more widely separated than in the teeth illustrated by Wright & Brown (loc. cit.).

Remarks. Haas (1936) recognised 6 subspecies of *L. natalensis* in Africa, but Hubendick (1951) found no clear geographic pattern in the distribution of variation in shell and anatomical characteristics. However, Mandahl-Barth (1954) divided *L. natalensis* into 3 subspecies, of which *caillaudi* included certain E. African forms and all the species described from Ethiopia by Bourguignat. Specimens from the Victoria Nile, which are distinguished from *L. natalensis* by characteristics of the shell and prostate gland, are identified by the same author as *L. exserta* Martens, which was originally described from the highlands of Ethiopia. According to the proportions given by Mandahl-Barth the approximate values of the ratio L/ML vary between 1·13 (*L. natalensis nyansae*) and 1·50 (*L. exserta*). Many of the specimens in the present collection have the proportions of *L. natalensis caillaudi*, but as a considerable number conform to the subspecies *natalensis natalensis* and others to *L. exserta*, the material is not assigned to a subspecies.

None of the Ethiopian specimens dissected has a prostate gland like that described for *exserta* from the Victorian Nile by Mandahl-Barth, and the identity of the Uganda form with Martens' species must be considered doubtful. All the shells of *Lymnaea* obtained from Lake Tana, the type locality of *L. caillaudi*, closely resemble Bourguignat's description of this species and they are distinctive (pl. 2, 11) in comparison to all the other samples.

Radix pereger recorded by Piersanti (1940) appears to represent a small shell of *L. natalensis*.

Distribution. As is the case in many other parts of Africa *L. natalensis* is widely distributed and abundant in Ethiopia, occurring in a variety of habitats including shallow fast-flowing streams and lakes.

Family **PLANORBIDAE**

Subfamily **BULININAE**

BULINUS Müller

Bulinus truncatus species group

Bulinus truncatus sericinus (Jickeli).

Bulinus truncatus (Audouin, 1827) sensu Connolly, 1928 : 177.
Physa contorta Michaud, 1829 sensu Martens, 1869 : 99 ; Blanford, 1870 : 476 ; Bourguignat, 1883 : 126 ; *Isidora contorta ;* Pollonera, 1898 : 12 ; Neuville & Anthony, 1906 : 274, fig. 9.
Isidora brocchii Ehrenberg, 1831 sensu Pollonera, 1898 : 12.
Physa natalensis? Kuster, 1841 sensu Martens, 1869 : 214 ; *Bulinus natalensis* ; Connolly,

1928 : 175, figs. 3 & 4 ; Bacci, 1940 : 455 ; Piersanti, 1941 : 276, fig. 40 ; *Physa natalica ;* Bourguignat, 1883 : 126.

Bulinus (*Diastropha*) *raymondianus* var. *porrecta* (Martens, 1874) sensu Piersanti, 1941 : 275, fig. 39.

Isidora sericina Jickeli, 1874 : 194, pl. 7, fig. 11 ; *Bulinus* (*Bulinus*) *sericinus ;* Mandahl-Barth, 1957b ; *Bulinus sericinus ;* Wright & Brown, 1962.

Isidora schackoi Jickeli, 1874 : 197, pl. 7, fig. 12 ; *Bulinus schackoi ;* Connolly, 1928 ; *Isidora schackoi* mut. *minima* Pollonera, 1898 : 12.

Physa coulboisi ? Bourguignat, 1888 sensu Neuville & Anthony, 1908 : 266, fig. 5.

Physopsis africana (non Krauss, 1848) Neuville & Anthony, 1908 : 266, fig. 5.

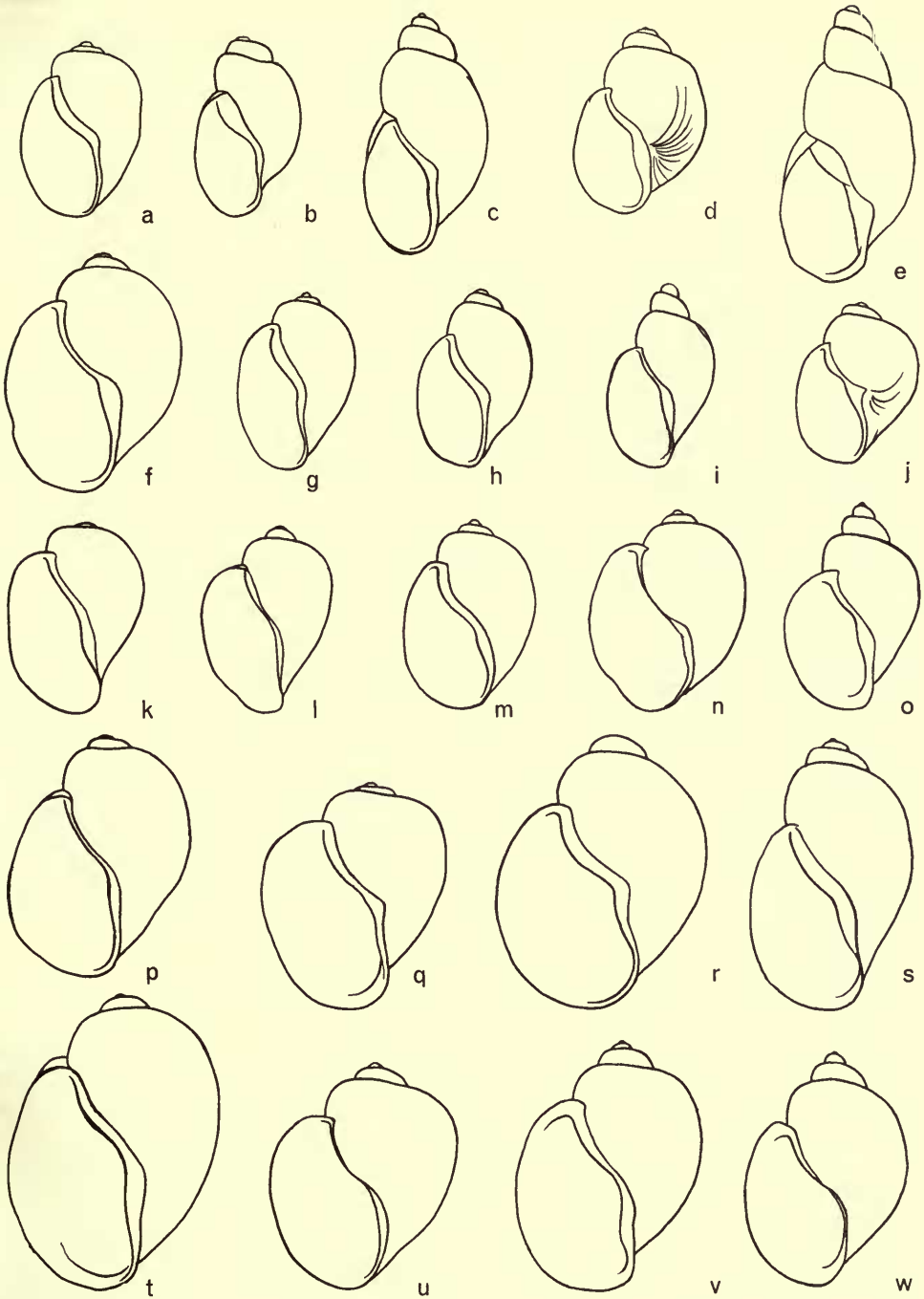
Localities. Arussi : Lake Zwai, (150) ; 50 km. approx. from Shashamanne on Soddu road, 2 samples, (100) ; River Awash, S. of Nazareth, 2 samples, (16). Begemeder : 38 km. N. of Gondar on Asmara road, (100) ; 66 km., 77 km., 97 km. and 116 km. N. of Gondar, (50) ; 279 km. N. of Gondar, (4) ; Lake Tana at Gorgora, (2). Choa : Lake Biete Mengest, (150) ; Lake Hora, (150) ; Lake Bishoftu, (20) ; swamp N. of Debra Zeit town, (100) ; Akaki River at Akaki, (40) ; Moggio River at Moggio, (5) ; River Awash on Addis Ababa–Jimma road, (2) ; 21 km. E. of Wolisso on Jimma road, (10) ; 10 km. W. of Ambo on Lekemti road, 2 samples, (20) ; Lake Wonji, (20) ; 16 km.–185 km. N. of Addis Ababa on Debra Markos road, 8 samples, (350) ; 67 km. and 130 km. N. of Addis Ababa on Asmara road, (40) ; 12 km. N. of Debra Sina, (2) ; 96 km. N. of Robi, (6). Eritrea : 22 km.–83 km. S. of Asmara on Gondar road, 4 samples, (90) ; 3 km.–38 km. N.W. of Asmara on Cheren road, 7 samples, (120) ; 66 km. S. of Asmara on Addis Ababa road, (20) ; River Toquor near Mekerka, (37). Harar : Lake Aramyia, (300) ; 17 km. (Langhei village) and 43 km. on Carsa road from junction with Dire Dawa–Harar road, (350). Kaffa : 26 km. approx. W. of Sokuru on Jimma road, (2) ; 22 km. W. of Assendabo on Jimma road, (25) ; 4 km. E. of Jimma on Addis Ababa road ; (20) ; 4 km. W. of Jimma on Bonga road, (40) ; 38 km. N. of Jimma on Agarro road, (2). Sidamo : Lake Margherita, east shore, (40). Tigre : 167 km. and 200 km. S. of Asmara on Addis Ababa road, (60) ; 341 km. S. of Asmara, (2) ; Lake Ashangi, N.E. shore, (100). Wollo : 1 km. W. of Batei, N. of Kombolchia road, (30) ; 1 km. within N. boundary of Dessie on Asmara road, (20) ; 8 km. and 30 km. N. of Dessie on Asmara road, (60) ; Lake Haik, S. shore, (130).

Shell (Text-fig. 10)

Because of the great variation in shell shape it is necessary to consider separately several more or less distinct forms. In many of the populations occurring on the

---

Fig. 10. *Bulinus truncatus sericinus* and *Bulinus* sp. (*truncatus* group), shell outlines drawn by camera lucida. a–t, *B. truncatus sericinus*. a–c, Choa, 72 km. N. of Addis Ababa on Debra Markos road. d, Eritrea, reservoir 4 km. N.W. of Asmara on Cheren road. e, Begemeder, 38 km. N. of Gondar on Asmara road. f, Choa, 12 km. N. of Debra Sina on Asmara road. g–i, Eritrea, River Toquor near Mekerka. j, Eritrea, 38 km. N.W. Asmara on Cheren road. k, m, Wallo, Lake Ashangi. l, Sidamo, Lake Margherita. n, o, Arussi, 5 km. S. of Adamitullo. p, t, Choa, Lake Hora. q, r, Choa, Lake Biete Mengest. s, Choa, swamp N.W. of Debra Zeit town. u–w, Arussi, *Bulinus* sp. from Lake Awasa.


a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u
v
w

plateau the shell is narrower than is usual in other parts of the range of *B. truncatus* in N.E. Africa, and in some populations the spire is unusually elongated (Text-fig. 10c and e). Further characteristics, developed to a variable extent, are the relatively great length of the ultimate whorl, and the somewhat shouldered appearance of the apical whorls. Some samples contain a wide range of shell shapes (Text-fig. 10 a–c, g–i), but others are uniform. The kind of shell described above is common at moderately high altitudes in Ethiopia, but in the same regions populations with small, widely umbilicate, short-spired shells occur (d and j), and also a few populations reaching a relatively large maximum size (f). Maximum individual size varies widely between populations, generally the largest shells do not exceed 15 mm., and many populations appear to be full grown at less than 10 mm. Exceptionally large specimens were present in a reservoir near Asmara.

Largest shell : L = 21·5 mm. ; ML = 12·9 mm. ; W = 11.8 mm. ; 5 whorls. Transverse ribs, arranged regularly on the upper whorls, are present in at least some shells in every sample, and are overlain by flaps of periostracum in many specimens. A faint spiral sculpture is occasionally present. The columella is slightly twisted in some samples. Four samples of particular interest from the plateau region are described below.

1. Eritrea : River Toquor near Mekerka (Text-fig. 10, h–j). Type locality of *Isidora schackoi* and *I. sericina* Jickeli, 1874. Text-figure 10 illustrates the variation in the length of the spire.

Largest shell : L = 10·7 mm. ; ML = 7·3 mm. ; W = 6·6 mm. ; 4 whorls.

Ratio L/ML ranges between 1·15 and 1·50 (37 shells).

2. Begemeder : 38 km. N. of Gondar (pl. 2, 2 and Text-fig. 10e). Exceptionally long-spired shells, some of which have the surface of the ultimate whorl conspicuously malleated.

Largest shell : L = 13·3 mm. ; ML = 8·0 mm. ; W = 6·8 mm. ; $4\frac{1}{2}$ whorls.

Ratio L/ML ranges between 1·51 and 1·80 (20 shells).

3. Tigre : Lake Ashangi (Text-fig. 10m). Relatively short-spired shells with rounded apertures. Fine, irregular transverse ribs are present, and faint spiral sculpture is present on the apex.

4. Wollo : Lake Haik. An exceptionally small form.

Largest shell : L = 8·4 mm. ; ML = 6·5 mm ; W = 5·5 mm. ; $3\frac{1}{4}$–$3\frac{1}{2}$ whorls, (sample of approx. 100).

Populations that are similar to some of those of the plateau were found at lower altitudes south of Addis Ababa : between Addis Ababa and Debra Zeit ; between Shashamanne and Soddu, and in the River Awash south of Nazareth. These localities, with the exception of the River Awash, are elevated in relation to the floor of the Rift Valley. The populations occurring in the Bishoftu Crater Lakes at Debra Zeit, and in the Rift Valley Lakes, are distinctive and are described below.

5. Choa : Bishoftu Crater Lakes (Text-fig. 10, p–r and t). Collections were made in Lakes Biete Mengest, Hora, and Bishoftu (see Mohr, 1961 for terminology). All the shells are relatively wide, with a more or less evenly rounded aperture that has an obtuse angle above.

Largest shell : L = 14·2 mm. ; ML = 9·8 mm. ; W = 10·5 mm. ; 4+ whorls, (L. Biete Mengest).

Ribs are well developed in both the shell and the periostracum, and spiral sculpture is exceptionally well developed in the Lake Hora population. In a nearby swamp (W. of Debra Zeit town), the shells have longer spires and narrower apertures (Text-fig. 10s).

6. Lakes Zwai and Margherita (Text-fig. 10k and l). The shells have relatively large apertures compared to those of the plateau populations.

Anatomy

The mantle and genital organs of *B. truncatus sericinus* from near Debra Markos were described by Wright & Brown (1962). Mantle pigmentation, like shell shape, is often characteristic of a particular population, but the value of pigmentation as a taxonomic character is reduced by the great variation that may be observed in samples from a small area. No characteristics in the gross morphology of the genital organs have been observed that can be correlated with the various shell shapes in the present collection, but it is likely that the size at which sexual maturity is reached in each population is related to the maximum size achieved in that habitat.

Wholly aphallic specimens (which were not present in the samples from near Debra Markos) are present in several of the samples, but the aphallic condition does not appear to be correlated with either shell shape or geographical distribution. Of 20 samples examined, 7 contain aphallic individuals. The proportions of aphallic specimens found range between 8 per cent. (Lake Bishoftu, 25 specimens), 92 per cent. (Lake Zwai, 25 specimens), and 100 per cent. (Lake Margherita, 10 specimens).

Radula (Text-figs. 19–21)

More or less distinctive characteristics are present in each sample of radulae that has been examined, and it is likely that a detailed analysis would reveal a variation comparable to that observed in the shell. The central tooth usually bears two cusps, but in one radula the entire row of centrals bears a single median cusp. The mesocone of the lateral teeth is occasionally bluntly pointed, but generally approaches an arrow-head shape which is very obvious in the Lake Ashangi specimens (Text-fig. 21). One or two interstitial cusps (Wright & Brown, loc. cit.) may be present on the lateral teeth. Transition between the lateral and marginal teeth usually takes place between teeth 6 and 8 with the development of additional cusps between the endo- and the mesocone, and lateral to the ectocone (Text-figs. 19, 20). The mesocone can be recognised in many of the marginal teeth, but up to nine more or less similar cusps may be present on the median side of these teeth, and a variable number of small cusps is present on the lateral side.

Folds or ridges, which appear to correspond to the " fluting " described by Stiglingh et al (1962), are present on the endo- and mesocones of the lateral teeth of many specimens. Folding is particularly well developed on the cusps of the lateral teeth of specimens from 38 km. N. of Gondar, which have broadly based endocones of a characteristic shape (Text-fig. 19).

Remarks. Apart from locally described species and varieties, and a single shell identified by Neuville & Anthony as *B. coulboisi*, shells of *Bulinus* (*Bulinus*) from

Ethiopia have been identified as either Egyptian or South African species by previous authors. Mandahl-Barth (1960) and Wright & Brown (1962) regard the locally described forms as synonymous with *B. sericinus* (Jickeli), belonging within the *B. truncatus* group. The present collection provides information about the variation of the *Bulinus truncatus* group which is of value in the interpretation of the interrelationships between the Ethiopian forms and their relationship to the *Bulinus* of other parts of Africa.

Only 37 moderately sized specimens were collected in the type locality of *B. sericinus* and *B. schackoi*, but the series contains sufficient variation in spire height to encourage the view that elongated shells of the *schackoi* type may be considered as part of the continuous variation of a population of *B. sericinus* (Wright & Brown, loc. cit.). However, although some other samples in the present collection contain a more or less complete intergradation between the *sericinus* and *schackoi* types of shell, many large samples contain a comparatively restricted range of variation. Sample 2 described above consists almost entirely of long-spired *schackoi* shells, of which the range of variation of L/ML scarcely overlaps that of any other populations. Such distinctive populations may be produced either by genetic characteristics of the snails, or ecophenotypic effects of the habitat, or both factors acting together. The occurrence of small *schackoi* snails together with small *sericinus* in the same habitat, where they have presumably experienced the same environmental influences, is evidence that there is some genetic difference between the forms.

It has long been appreciated that there is a close resemblance between the shells of some Ethiopian *Bulinus*, and those of *B. natalensis* (Krauss) of South Africa. Specimens from northern Ethiopia have been identified as *natalensis* (Martens, 1869 and Bourguignat, 1883), as have examples from in or near the Rift Valley Lakes (Connolly, 1928, Bacci 1940, Piersanti, 1941). Connolly divides specimens from the Bishoftu Crater Lakes (Bishoftu and Hora Harsadi) and Lake Zwai into two forms, one of them probably conspecific with *natalensis* and the other somewhat different, which occurred together in one lake (Bishoftu). Specimens similar to those described by Connolly were collected during the recent expedition in Lakes Zwai, Bishoftu, and Biete Mengest (=Hora Harsadi of Connolly). In addition, a further population has been found (Lake Hora, see 5 above) with exceptionally well developed spiral sculpture. All the lateral radula teeth examined in Ethiopian specimens have arrow-head shaped cusps, in contrast to the South African *Bulinus* (*Bulinus*) which are placed in the *Bulinus tropicus* group (including *natalensis* Krauss), having sharply pointed cusps (Mandahl-Barth, 1957b, and 1962). However, a close relationship between Ethiopian and South African forms is not precluded, as a form of *B. tropicus* from Transvaal which possesses arrow-head shaped cusps has been described by Stiglingh et al. (1962) which is considered by Mandahl-Barth (pers. comm.) to represent *B. natalensis* (Krauss) and to belong within the *truncatus* group.

It is thus a matter for conjecture whether certain populations of *Bulinus* (*Bulinus*) occurring in Ethiopian lakes are related most closely to South African *Bulinus* with arrow-head shaped cusps, to populations of the *B. truncatus* group occurring

at relatively low levels in N.E. Africa, or to *B. truncatus sericinus* of the Ethiopian plateau. Dr. J. B. Burch (in. litt.) has found differences in chromosome number between several populations of the *B. truncatus* group in N.E. Africa (see under *Bulinus* sp. below), and it is to be hoped that such studies will be of value in elucidating the relationships discussed above. At present, the inclusion of the varied forms in *B. truncatus sericinus* is provisional.

Distribution. *B. truncatus sericinus* is widely distributed in Ethiopia above an altitude of about 1,500 m. (5,000 ft.), and has been found at 2,945 m. (9,600 ft.) (38 km. N. of Gondar). This subspecies is regarded as including *Bulinus* from Western Aden Protectorate (Wright, 1963b), but the records of *B. sericinus* from other parts of Africa probably refer to other forms of *Bulinus*.

Bulinus sp.

Localities. Arussi : 5 km. approx. S. of Adamitullo (between Lake Zwai and Bulbulla River) (6)*. Sidamo : Lake Awasa (400).

Shell (pl. 2, 4 and Text-figs. 10u–w)

Most of the shell length is contributed by the ultimate whorl, the apical whorls forming a small sharp spire. The aperture is large, more or less evenly rounded, and has an obtuse upper angle that is frequently more than 90 degrees. As a result of the steep curvature of the upper part of the whorls the suture is deep. Fine transverse ribs are present, but there are no free flaps of periostracum. Spiral sculpture is well developed on the apices of many shells, and is occasionally present on some parts of the ultimate whorl. Fresh shells are pale straw-coloured or almost white.

Largest shell : L=13·8 mm.; ML=10·5 mm.; W=10·4 mm.; four and three-eighths whorls.

Anatomy

Out of 25 specimens dissected, 9 are aphallic and 6 lack penis sheaths.

Radula (Text-fig. 22)

The lateral teeth have arrow-head shaped cusps but the radula teeth appear to be significantly smaller than in specimens of the same size from plateau populations of *B. truncatus sericinus*.

Remarks. Living snails have a characteristic blue-grey bloom ; approximately 10 per cent. of those collected lacked dark pigment and appeared to be albinos.

Dr. J. B. Burch (1964) finds that the haploid chromosome number of specimens collected in Lake Awasa is 18, in contrast to 36 in *B. truncatus* from Egypt and Iran, and 72 in laboratory bred stock of *B. truncatus sericinus* collected by Dr. C. A. Wright in Western Aden Protectorate. Burch (1960) has also reported a haploid number of 18 in the *Bulinus tropicus* group. The low chromosome number of the Lake Awasa *Bulinus*, and the similarity of the shells to sub-fossil shells from the vicinity of Lake Zwai (Text-fig. 10), are facts that in conjunction suggest that the form may be an ancient one now restricted in range.

Bulinus africanus species group

B. africanus ovoideus (Bourguignat)

*Physopsis ovoide a*Bourguignat, 1879 : 16 ; *B.* (*P.*) *africanus ovoideus* ; Mandahl-Barth, 1957 : pls. 17 & 18.

Localities. Begemeder : 14 km. N. of Medhanie Alem on Asmara road (27) ; Lake Tana at Gorgora (21) ; 8 km. N. of Gorgora (5). Kaffa : 44 km. E. of Jimma town boundary on Addis Ababa road (80).

Shell

The outstanding characteristics of each sample are described below.

1. Medhanie Alem (pl. 2, 9, 12). The spire is relatively short and sharp and the surface of the ultimate whorl is evenly curved with no trace of a shoulder. Spiral microsculpture is very well developed on the apex, and extends nearly to the aperture in several specimens. Where the microsculpture extends to the lowest whorl, the nodules become elongated and scarcely elevated from the surface, giving the appearance of rows of striae.

Largest shell : L=17·7 mm.; W=13·1 mm.; ML=11·4 mm.; $4\frac{3}{4}$–5 whorls.

2. Lake Tana (pl. 2, 8, 11). The spire is relatively longer than in the preceding sample but the apical whorls are less exserted and not sharply pointed. The whorls are flattened near the suture so that a blunt shoulder is formed. Spiral microsculpture similar to that described above is present, but is less distinct. All the larger shells have a thickened ridge at approximately the same distance from the aperture, indicating that growth has been temporarily interrupted.

Largest shell : L=11·7 mm.; ML=9·1 mm.; W=7·8 mm.; $4\frac{3}{4}$ whorls.

3. Kaffa (pl. 2, 13–15). The larger specimens are narrow with rounded apical whorls and comparatively long spires. The shell colour is not brown as in the preceding samples but whitish to pale horn. The aperture lengths and shell widths are smaller than in Medhanie Alem shells of the same length over the whole of the size range, and more whorls have been completed at the same length. Microsculpture similar to that of the preceding samples is present. At, or near, the aperture of all but the smallest shells is a light coloured band which marks a temporary cessation of growth.

Largest shell : L = 16·2 mm. ; ML = 11·4 mm. ; W = 9·3 mm. ; 5 whorls.

Anatomy

In all the samples the mantle is similarly pigmented with distinct dark blotches (Text-fig. 18). The penis sheath is longer and broader than the preputium, the range of PS/PP lying between 1·07 and 1·73 (20 specimens dissected).

Radula (Text-fig. 24)

Transition between the lateral and the marginal teeth is marked by the development of a small cusp between the endocone and the mesocone, which usually takes place at the 10th tooth (12 radulae examined).

Remarks. The shells collected on the north shore of Lake Tana show some resemblance to *Bulinus globosus*. Similar shells collected by Dr. N. Ayad near Bahr Dahr on the south shore were identified as this species by Mandahl-Barth (in

Ayad, 1956). However, the copulatory organs of the specimens from Gorgora are similar to those from near Medhanie Alem, the shells of which resemble *B. africanus ovoideus*, and it is probable that this species is present on both the north and south shores of the lake. With regard to the large number of apparently suitable habitats that were searched in which no *B. africanus* were found, it may be concluded that populations are widely separated. This kind of distribution would favour the development of distinct local characteristics as described above in the case of the shell.

DISTRIBUTION. The present records from Begemeder appear to be the most northerly for *B. africanus* in East Africa. *B. africanus ovoideus* appears to have a wide range on the Ethiopian plateau but is not abundant ; it is widely distributed in Kenya and Uganda and extends into the Congo and Tanganyika (Mandahl-Barth, 1957b).

Bulinus ugandae Mandahl-Barth

Bulinus (*Physopsis*) *globosus ugandae* Mandahl-Barth, 1954 : 114, figs. 55a–h ; *B.* (*P.*) *ugandae* Mandahl-Barth, 1957.

LOCALITY. Sidamo : Lake Margherita, east shore (16).

Shell (pl. 2, 6, 7 and 10)

The majority are moderately high-spired, with rounded whorls that are more or less shouldered near the suture.

Largest shell : L = 14·7 mm. ; ML = 10·9 mm. ; W = 11·3 mm. ; $4\frac{1}{2}$ whorls. The upper angle of the aperture is obtuse and frequently a right-angle ; the inner edge of the aperture is folded narrowly over the umbilicus which is open. Truncation of the columella is so slight in many specimens that it resembles the oblique twisting occasionally present in *Bulinus* (*Bulinus*). Irregular transverse ridges of varying size are scattered over the whole shell surface, and the second whorl of some specimens bears spiral ridges which cross the transverse ridges forming a poorly defined network of elevations and pits. In some specimens there is a very fine spiral microsculpture over the rest of the shell surface formed by rows of shallow ridges and furrows but never consisting of well defined nodules as in *B. africanus ovoideus*.

Anatomy (Text-fig. 17)

In contrast to *B.* (*P.*) *africanus ovoideus* the mantle lacks definite patches of pigment and is evenly grey in appearance (Text fig. 17). On the inner surface there is a long fold between the rectum and the kidney extending as far back as the posterior end of the kidney, and a large fold along the whole length of the surface of the kidney.

As all the copulatory organs are everted the length of the penis sheath can only be estimated as equal to or slightly longer than the preputium.

Radula (Text-fig. 23)

Transition between the lateral and the marginal teeth takes place earlier than in the preceding species, at about the 8th or 9th tooth (4 radulae examined).

REMARKS. Although columellar truncation and spiral microsculpture are almost absent in several shells, the presence of a long renal fold confirms that these specimens

belong to the *Bulinus africanus* species group. There is a close resemblance to shells of *B. ugandae* from Kosti (Sudan) and Kisumu (Kenya) figured by Mandahl-Barth (1957b, figs. 40d and 41b), and it is not surprising that the range of this species should extend into south-west Ethiopia. Comparison with *B. abyssinicus* (Martens) from Somalia (Mandahl-Barth, 1957c) shows that in general appearance the Lake Margherita specimens are closer to *B. ugandae*. However, as the original description states that spiral microsculpture is completely absent from the apex of *B. ugandae*, the presence of some spiral microsculpture in the Lake Margherita shells might be taken to indicate a close relationship with *B. abyssinicus*. This is not an important point of resemblance though, because as *ugandae* was originally described as a subspecies of *B. globosus* they are probably closely related, and the presence of slight spiral sculpture in *ugandae* is not surprising as it is frequently well developed in *globosus*.

Distribution. It is likely that *B. ugandae* occurs elsewhere in Ethiopia but the species is probably rare as only a single colony was found during several days collecting on the shore of Lake Margherita. Five specimens with eroded apices collected in Lake Stephanie and identified by Piersanti (1941) as *B.* (*P.*) *africanus* may represent *B. ugandae*. The range of this species is confined to north-east Africa including Uganda, Tanganyika, Kenya and Sudan.

Bulinus forskali species group

Bulinus forskali (Ehrenberg)

Isidora forskalii Ehrenberg, 1831 : 20 ; Jickeli, 1874 ; Pollonera, 1898 ; Neuville & Anthony, 1908 ; *Physa forskalii ;* Martens, 1869 ; Morelet, 1872 ; Bourguignat, 1883 ; Neuville & Anthony, 1906 ; *Pyrgophysa forskalii ;* Neuville & Anthony, 1905 ; *Bulinus forskali ;* Connolly, 1928 ; Haas, 1932 ; *Bulinus* (*Pyrgophysa*) *forskalii ;* Bacci, 1941 ; *Bulinus* (*Bulinus*) *forskalii* : Mandahl-Barth, 1957b & 1960.

Physa forskalii var. *elatior* Martens, 1866 : 100.

Bulinus (*Isidora*) *forskali* var. *cylindrica* Piersanti, 1941 : 275, fig. 38.

Pyrgophysa scalaris (non Dunker, 1845) Neuville & Anthony, 1905.

Localities. Arussi : Lake Zwai, N.W. shore (15) ; 1 km. S. of River Awash on Nazareth-Asella road (15). Begemeder : Lake Tana at Gorgora (5). Sidamo : Lake Margherita, east shore (50) ; army barracks at Neghelli (2) ; artificial pool 10 km. approx. S. of Uachile Wells (50). Wollo : 62 km. S. of Kombolchia on Addis Ababa road (20).

Shell (pl. 3, 1 and 2)

Few of the shells in any sample exceed 8·5 mm. in length, at which size about $5\frac{1}{2}$ whorls have been completed (Text-fig. 27).

Largest shell : L = 10·6 mm. ; ML = 4·3 mm. ; W = 3·5 mm. ; $6\frac{1}{4}$ whorls (Lake Tana). The aperture occupies less than half of the total length of the shell length in specimens of more than 3 mm. shell length (Text-figs. 25 and 26). The shoulder on the upper whorls is acute in many specimens, and frequently bears a distinct carination (pl. 3, 2). Irregular growth ridges of varying size are present, and there are regularly spaced ribs on at least the second and third whorls of most shells.

Anatomy (Text-figs. 11 and 28)

The copulatory organ (Text-figs. 11a–c and 28) is small in comparison to that of *B. scalaris*, with a penis sheath that is narrower than the preputium and less than twice its length in most specimens. In the Lake Margherita sample the ratio PS/PP ranges between 0·95 and 2·42 with a mean of 1·57 (14 specimens).

Remarks. *Bulinus fischerianus* (Bourguignat), the only species of the *Bulinus forskali* group originally described from Ethiopia, is provisionally placed within the synonymy of the *B. scalaris* (Dunker) in the present paper (see below). As the only other members of the *forskali* group described in north-east Africa are *B. forskali* (Ehrenberg) and two other Egyptian forms belonging within the synonymy of this species (Mandahl-Barth, 1957b), it remains to compare the present *Bulinus* with *B. beccarii* (Paladilhe, 1872) which has recently been recorded by Wright (1963b) from the Western Aden Protectorate.

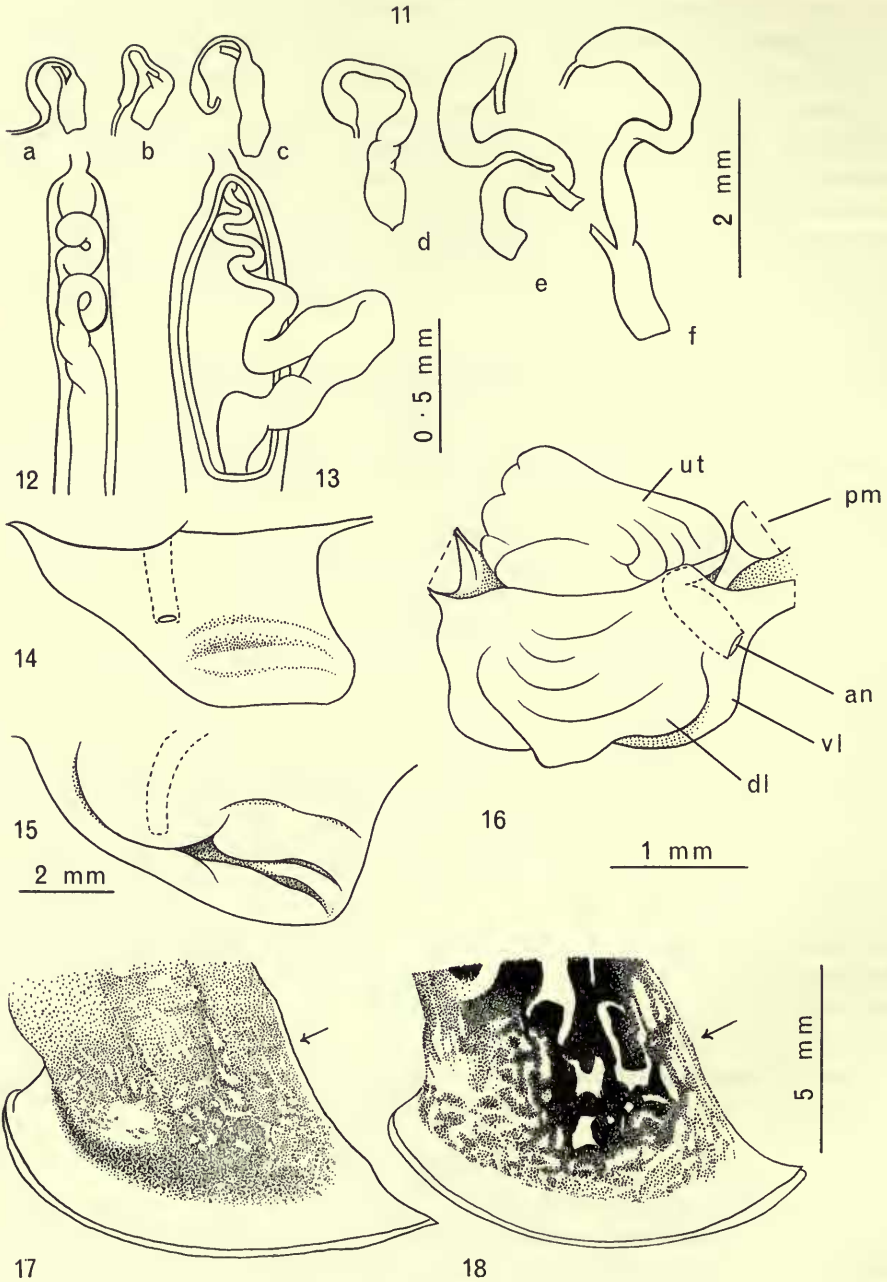
Shells of the Ethiopian specimens here identified as *B. forskali* have the transverse ribs and carination far more strongly developed than do specimens of *B. beccarii* from Western Aden Protectorate. Wright described differences in the shell and radula between *beccarii* and the other members of the *B. forskali* group, and concluded that the part played by *beccarii* as an intermediate host of *Schistosoma haematobium* suggested a relationship with *B. senegalensis* or *B. cernicus*. There is no evidence that the Ethiopian *Bulinus* in question act as an intermediate host of *S. haematobium*, and the waters in which they were found are still in contrast to the slowly flowing water inhabited by *beccarii*. As no significant differences have been observed between shells of Ethiopian *forskali* and specimens from Egypt and Kenya, it is concluded that the Ethiopian populations form part of the extensive north-east African range of this species.

Distribution. *B. forskali* is recorded from relatively low altitudes in southern Ethiopia by Martens (1866), Haas (1932) and Piersanti (1941), and there are several records in eastern Eritrea also from low altitudes. The species is recorded from Lake Zwai (Connolly, 1928), and from southern Choa (Neuville & Anthony, 1908). The present records go some way towards connecting these scattered areas of distribution, and suggest that the species has a widespread distribution in the south extending at least as far north as the River Awash at an altitude of about 5,000 feet. *B. forskali* appears to be absent from the vicinity of Addis Ababa and Asmara, but its presence in southern Wollo Province and Lake Tana suggests that there is also an extensive range of scattered distribution on the plateau. *B. forskali* is widely distributed in Egypt and Africa south of the Sahara, but does not appear to have been recorded at such high altitudes outside Ethiopia.

Bulinus scalaris (Dunker)

Physa scalaris Dunker, 1845 : 164, 1853 : pl. 2, figs. 5 & 6.
Physa fischeriana Bourguignat, 1856 : 146, pl. 2, figs. 1–3 ; Bourguignat, 1883 ; *Physa fischeri ;* De Rochebrune & Germain, 1904.

Localities. Begemeder : 4 km. N. of Gorgora to 248 km. S. of Asmara, 10 samples (230). Kaffa : 44 km. E. of Jimma town boundary (17).


11
a
b
c
d
e
f
2 mm
0·5 mm
12
13
14
15
2 mm
ut
pm
an
vl
dl
16
1 mm
17
18
5 mm

Shell (pl. 3, 3)

Maximum individual size is greater than that of *B. forskali* in most of the samples. Largest shell : L = 12·5 mm. ; 6 whorls. The spire is relatively less narrow than that of *B. forskali*, the rate of increase in the number of whorls is slightly slower (Text-fig. 27), and the length of the aperture tends to be longer (Text-figs. 25 and 26). There is no shoulder on the lower whorls, but the upper whorls of many specimens are shouldered, though usually less acutely than in *B. forskali*. In a few specimens a slight carination is present. Regularly spaced ribs which are less well defined than in *B. forskali* are present on the upper whorls, and fine spiral sculpture is present in several samples.

Anatomy (Text-figs. 11, 13 and 28)

The copulatory organ (Text-figs. 11e and f) is larger than that of *B. forskali*, with a penis sheath that is wider than the preputium and at least twice its length in the majority of specimens. In a sample from 4 km. N. of Gorgora the ratio PS/PP ranges between 1·68 and 5·00 with a mean of 3·01 (19 specimens). The epiphallus (Text-fig. 13) is not as long as that depicted by Mandahl-Barth (1957b, p. 87), but from the length of the everted penis it is evident that the epiphallus is capable of extending at least twice the length of the sheath.

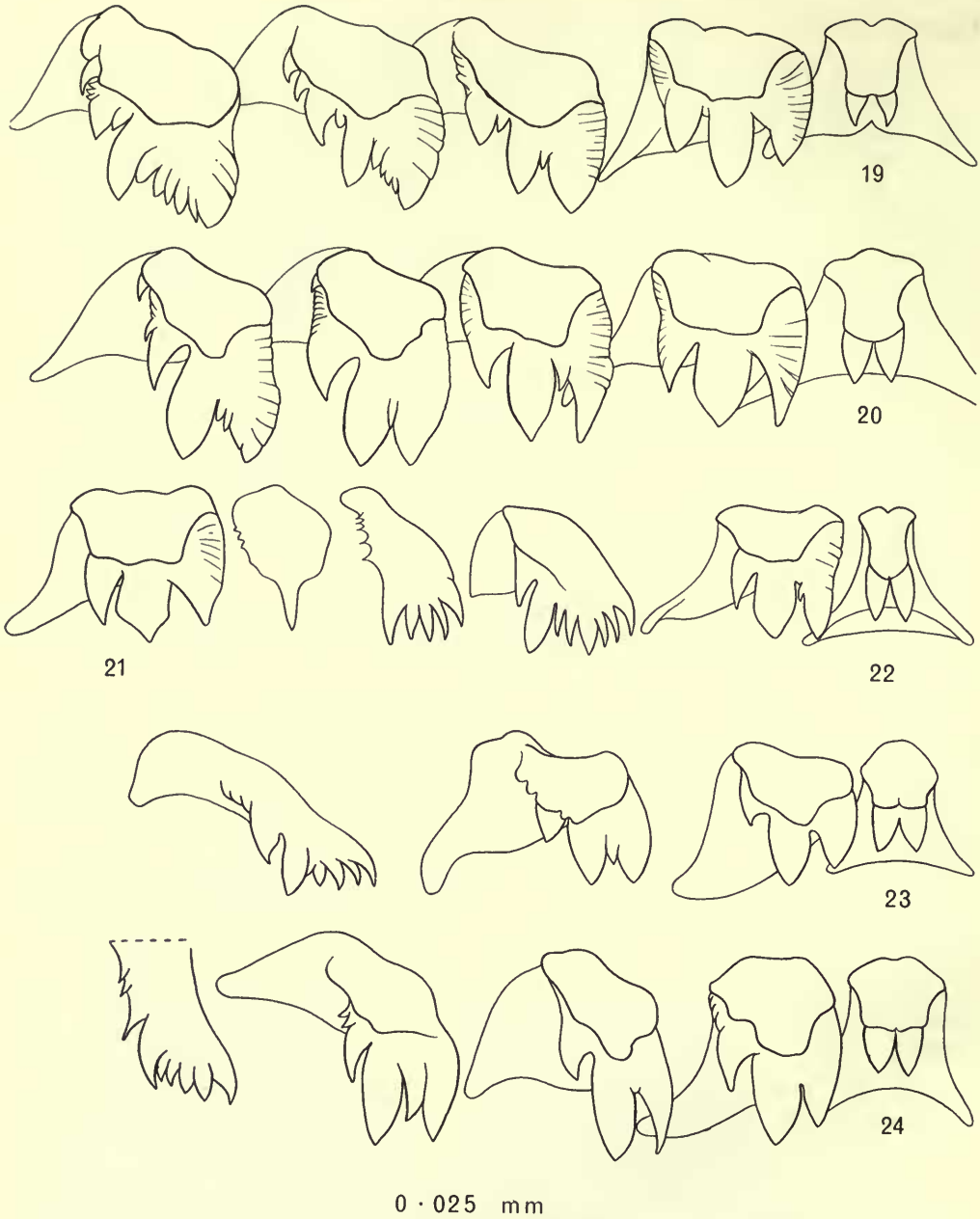
The vagina is everted to some extent in all of the specimens examined ; this condition was first recorded in *B. scalaris* by Mandahl-Barth (1960) and appears to be characteristic of fixed specimens of this species.

Remarks. Wright (1963a) points out that shells of *B. scalaris* (including specimens in the type series) are occasionally somewhat shouldered, and this is also the case in the present collection. It is thus impossible to contrast *B. scalaris* with *B. forskali* as having " not the faintest trace of a shoulder angle " (Mandahl-Barth, 1957b). However, *B. scalaris* can readily be distinguished from *B. forskali* by the shape and size of the copulatory organ, and the shape of the shell.

Bulinus fischerianus (Bourguignat) is tentatively included in the synonymy above because of the close resemblance between Bouguignat's figure of this species and many of the shells of *B. scalaris* in the present collection.

Distribution. The shell recorded from the River Moggio by Neuville & Anthony (1905) as *scalaris* and later (1908) figured as *forskali*, closely resembles the former species, which may thus occur at relatively low altitudes in southern Choa.

Fig. 11. Copulatory organs of a *B. forskali* from Lake Margherita,; b. *B. forskali* from Lake Zwai ; c. *B. forskali* from 62 km. S. of Kombolchia ; d. *Bulinus* sp. (*forskali* group); e. *B. scalaris* from 47 km. N. of Medhanie Alem ; f. *B. scalaris* from 4 km. N. of Gorgora. All specimens between 8·3 and 9·8 mm. shell length. Fig. 12. *Bulinus* sp. (*forskali* group), epiphallus seen by transparency through wall of sheath. Fig. 13. *B. scalaris* from 4 km. N. of Gorgora, wall of sheath dissected away to expose epiphallus. Fig. 14. *Ancylus* sp. from 15 km. N. of Dilla, pseudobranch. Fig. 15. *Ancylus fluviatilis* from 45 km. N. of Gondar, pseudobranch. Fig. 16. *Burnupia caffra* from 59 km. N. of Addis Ababa on Debra Markos road, dorso-lateral view of pseudobranch. Fig. 17. *Bulinus ugandae* from Lake Margherita, outer surface of mantle. Fig. 18. *Bulinus africanus ovoideus*, outer surface of mantle.



FIGS. 19–24. Radula teeth. FIGS. 19–21. *Bulinus truncatus sericinus*. FIG. 19. 38 km. N. of Gondar, central, 1, 6, 7, and 8. FIG. 20. River Toquor near Mekerka, central, 1, 6, 7, and 8. FIG. 21. Lake Ashangi, 1.

FIG. 22. *Bulinus* sp. (*truncatus* group) from Lake Awasa, central, 1, 10, 23 and 24. FIG. 23. *Bulinus ugandae* from Lake Margherita, central, 1, 9 and 15. FIG. 24. *B. africanus ovoideus* from 5 km. W. of Assendabo. central, 1, 9, 12 and 26.

However, other shells figured by these authors from Goro Gomoto, a nearby locality, resemble *forskali* more closely, and as populations of *forskali* are known from the south and east of this area (see records for Arussi), the Neuville & Anthony records are provisionally regarded as representing *B. forskali*.

Two widely separated groups of populations of *B. scalaris* have been found which may be part of a scattered distribution in small temporary habitats throughout the plateau of Ethiopia. The record of *B. fischeri* by De Rochebrune & Germain (1904) from the S.E. side of the Rift Valley may also represent this species.

Elsewhere in Africa *B. scalaris* is known to have a scattered distribution in Angola, Congo, N. Rhodesia, Kenya and Uganda.

Bulinus sp.

Locality. Begemeder : 4 km. N. of Medhanie Alem (approx. 322 km. S. of Asmara on Gondar road) (100).

Shell (pl. 3, 4)

Similar to that of *B. scalaris* apart from the relatively deeper suture.

Largest shell : L = 12·5 mm. ; ML = 5·4 mm. ; W = 4·9 mm. ; 6¼ whorls.

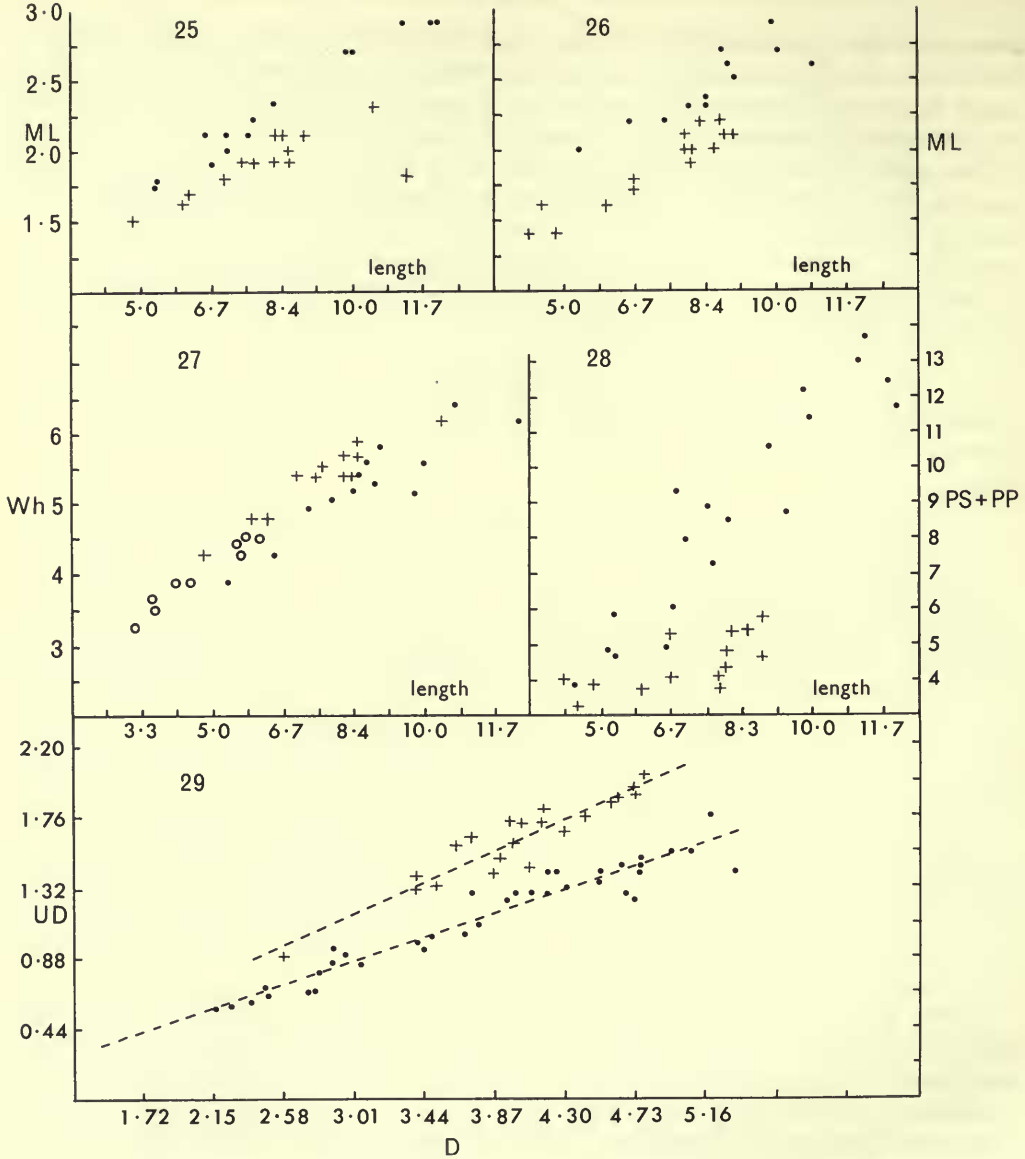
Anatomy (Text-figs. 11 and 12)

The copulatory organ (Text-fig. 11) is intermediate in size between that of *B. forskali* and *B. scalaris* but resembles that of *forskali* in the relationship between the dimensions of the penis sheath and the preputium. The ratio PS/PP varies between 0·75 and 1·57 with a mean of 1·04 (10 specimens), and the sheath is narrower than the preputium. A relatively short ephiphallus can be seen through the thin wall of the penis sheath (Text-fig. 12). The vagina is not everted as in *B. scalaris*.

Remarks. The characteristics of the shell and the copulatory organ are constant in a large number of specimens, but as only a single population was found it can only be provisionally regarded as representing a new form within the *B. forskali* group. It is an interesting possibility that the population is a hybrid one between *scalaris* and *forskali*, as in other parts of their range these species are found together with no signs of interbreeding (Mandahl-Barth, 1957b).

If this does prove to be a distinct form of *Bulinus* there is sufficient resemblance between the shell and that figured by Bourguignat to justify the use of the name *fischerianus*. The type locality of *fischerianus* was not precisely defined but it probably lies on the northern plateau of Ethiopia or Eritrea as Lake Tana is given by Bacci (1951) as the locality of other material attributed to the same collector (Verreaux).

Germain (1921) and Haas (1936) regarded *Bulinus fischerianus*, *B. beccarii* and *B. cernicus* as synonyms of *B. forskali*, while Mandahl-Barth (1957b) considered *cernicus* to be a distinct species with *fischerianus* and *beccarii* tentatively included as synonyms. As Wright (1963b) has recognised *beccarii* to be a distinct species in Western Aden Protectorate it is necessary to consider the relationship between *beccarii* and *fischerianus*. The status of *fischerianus*, which is an older name than either *cernicus* or *beccarii* was not discussed by Paladilhe who compared *beccarii* only to Egyptian forms of *Bulinus*. Direct comparison between the descriptions and



Figs. 25–29. Aperture length (ML) plotted against shell length (L), + =*Bulinus forskali* from 62 km. S. of Kombolchia ; · =*B. scalaris* from 4 km. N. of Gorgora. Fig. 26. Aperture length (ML) plotted against shell length (L), + =*B. forskali* from Lake Margherita ; · =*B. scalaris* from 47 km. N. of Medhanie Alem. Fig. 27. Number of whorls (Wh) plotted against shell length (L), + =*B. forskali* from 62 km. S. of Kombolchia ; o=*B. forskali* from 10 km. S. of Uachile Wells ; · =*B. scalaris* from 47 km. N. of Medhanie Alem. Fig. 28. Length of copulatory organ (PS+PP) plotted against shell length (L), + =*B. forskali* from Lake Margherita ; · =*B. scalaris* from 3 km. N. of Gorgora. Fig. 29. Shell diameter (D) plotted against umbilicus diameter (UD), + =*Gyraulus convexiusculus* from Tafwa, near Dahla, Western Aden Protectorate, collected and det. C. A. Wright ; · =*G. costulatus* from 1 km. S. of Debra Berhan.

figures of *fischerianus* and *beccarii* is hampered by the difference in size of the figured specimens, and one important feature distinguishing *beccarii*, the relatively large lowest whorl could be regarded as merely a juvenile character as the figured specimen of *beccarii* is only 4 mm. long. However, the manner of growth appears to be significantly different in the two forms, as at a length of 4 mm. *beccarii* has completed $4\frac{1}{2}$ whorls, whereas at 8 mm. length, *fischerianus* consists of only 5 whorls.

Subfamily **PLANORBINAE**

PLANORBIS Müller

Planorbis planorbis parenzani Bacci

Planorbis (*Tropidiscus*) *planorbis parenzani* Bacci, 1940 : 456, pl. 1, fig. 1.

Locality. Arussi : 5 km. approx. S. of Adamitullo (between Lake Zwai and Bulbulla River) (50).*

Shell (pl. 3, 15 and 16)

Largest specimen : D = 5·3 mm. ; UD = 2·3 mm. ; H = 2·0 mm. ; 4 whorls.

Remarks. These specimens are similar to sub-fossil shells described by Bacci (1940) in the maximum individual size and the rate of widening of the whorl, but differ in being relatively thicker and possessing a less acute basal angulation. This difference is seen most clearly in the aperture which is far more rounded in the present specimens. The chief characteristic distinguishing *P. planorbis parenzani* from *P. planorbis philippi* Monterosato is the relatively acute basal angulation in the former. As this characteristic is not well defined in the present shells, which like Bacci's specimens were collected from the plain that formed part of an ancient bed of Lake Zwai, it is doubtful whether the separation of the two forms is justified.

Distribution. No living specimens have been found of this *Planorbis* which appears to be closely related to the small forms of *Planorbis planorbis* that occur in N. Africa and the near East.

ANISUS Studer

Anisus natalensis (Krauss) species group

Anisus natalensis (Krauss)

Planorbis natalensis Krauss, 1848 : 83, pl. 5, fig. 9 ; ? *Planorbis natalensis ;* Blanford, 1870 ; *Gyraulus* (*Anisus*) *natalensis ;* Mandah-Barth in Ayad, 1956 ; *Anisus natalensis ;* Wright & Brown, 1962.

Planorbis abyssinicus Jickeli, 1874 : 215, pl. 7, figs. 21a–c ; Bourguignat, 1883 ; Pollonera, 1898 ; Germain, 1904 ; Neuville & Anthony, 1908 ; Connolly, 1928 ; *Planorbis abyssinicus* var. *gravieri* Germain, 1904 : 353.

Localities. Arussi : Lake Zwai, N.W. shore (30) ; 30–60 km. W. of Shashamanni on Soddu road, 4 samples (187). Begemeder : 66–97 km. N. of Gondar on Asmara road, 3 samples (220) ; Lake Tana at Gorgora (16). Choa : 22–318 km. N.E. of Addis Ababa on Asmara road, 5 samples (153) ; 32–185 km. W. of Ambo (50); Lake Wonji (15); 21 km. E. of Wolisso (21). Eritrea : 39 km. S. of Asmara on Gondar road (6) ; 8 and 38 km. N.W. of Asmara on Cheren road (145) ; 144 km. S. of Asmara on Addis Ababa road (193) ; 19 km. E. of Teramni on Decamere road (150). Harar: 43 and 46 km. on Carsa road from junction with Dire Dawa—Harar road (60). Kaffa : Between Kombi and Jimma, 4 samples (120) ; 4 km. W. of

Jimma on Bonga road (2) ; 34 km. N. of Jimma on Agarro road (3). Sidamo : Wondo (1) ; 30 and 45 km. south of Adolla (138) ; Lake Margherita (67). Tigre : Lake Ashangi, N.E. shore (10) ; 0·5 km. S. of Adowa on Gondar road (1). Wollo : Lake Haik, S. shore (50).

Shell

The majority of specimens resemble those from near Debra Markos described by Wright & Brown (1962), but there are relatively few shells in the present collection with as large and rounded an aperture as the shell illustrated in the earlier paper.

Largest shells : D = 7·0 mm. ; UD = 3·3 mm. ; H = 1·8 mm. (Lake Tana at Gorgora). D = 7·0 mm. ; UD = 3·5 mm. ; H = 1·8 mm. (Eritrea, 19 km. E. of Teramni).

Anatomy

Anatomical characteristics are similar to those previously described (Wright & Brown, loc. cit.). The anus opens near the tip of the pseudobranch, which is a simple lobe lacking any ridges. The ovotestis consists of up to 30 acini, which are arranged in two irregularly alternating rows. The spermathecal duct is stout, and may be wider than the vagina at the point of junction. There are up to 18 primary prostate gland lobes several of which may be subdivided. In many samples the copulatory organ is similar to that previously described, having the penis sheath slightly longer and about half as wide as the preputium, but in a few samples (e.g. Lake Zwai) the sheath is relatively shorter and narrower. The penis is similar to that of Debra Markos specimens in appearance, but a few specimens have now been observed in which there is some evidence that the cuticularised part of the penis is formed in a manner similar to that described by Hubendick (1958) for *Gyraulus*. The question of the homology of the terminal part of the penis of *A. natalensis* with the stylet of *Gyraulus* species can only be decided when the development of the penis has been studied in detail.

Remarks. Three differing accounts of the anatomy of *Anisus natalensis* have been recently published (Azevedo et al. 1961, Wright & Brown 1962, and Demian 1962). No specimens from the type locality (Umgeni Valley, Natal) appear to have been studied, but Wright & Brown examined specimens from Transvaal in which the penis was found to have a long cuticularised portion similar to that of Ethiopian specimens. As observations on the copulatory organ indicate that there may be more than one form of *Anisus* with this kind of penis in Ethiopia, the present specimens are provisionally referred to the *A. natalensis* species group. It should be noted that the specimen of *natalensis* illustrated by Krauss is far thinner with a more flattened aperture than in any Ethiopian specimen, or that illustrated by Azevedo et al. from Mozambique.

Specimens of *A. natalensis* from Tanganyika described by Demian possess a very small terminal penial stylet which is different to that of the Ethiopian and Transvaal specimens. A small stylet has also been described in *A. misellus* Morelet from Angola (Wright, 1963a). Another condition is described by Azevedo et al. (loc. cit.) in specimens from Mozambique which have a prostate gland consisting of a single lobe and a short penis with a terminal opening that lacks any stylet.

DISTRIBUTION. Snails of the *A. natalensis* group are widely distributed in Ethiopia and are often abundant ; a population was found at 2,890 (9,400 ft. approx.) in northern Choa. The presence of a similar penis in South African specimens indicates that this form has a widespread range in Africa.

GYRAULUS Charpentier

Gyraulus costulatus (Krauss)

Planorbis costulatus Krauss, 1848 : 83, pl. 5, fig. 8 ; *Planorbis costulatus* var. ; Jickeli, 1874 ; *Gyraulus costulatus ;* Mandahl-Barth in Ayad, 1956 ; Wright & Brown, 1962.
Planorbis stelzneri Martens (non Dohrn), 1869 : 212.
Planorbis aethiopicus Bourguignat, 1883 : 128 ; Jickeli, 1874 : pl. 7, fig. 23.
Caillaudia angulata Bourguignat, 1883 : 129 ; Jickeli, 1874 : pl. 7, fig. 22 ; Piersanti, 1941.
Planorbis gibbonsi Nelson, 1878 sensu Neuville & Anthony, 1908 ; Connolly, 1928.

LOCALITIES. Begemeder : 97 km. N. of Gondar on Asmara road (6). Choa : Between 11 km. N.E. of Addis Ababa and 1 km. S. of Debra Berhan on Asmara road, 5 samples (230) ; 32–59 km. N. of Addis Ababa on Debra Markos road, 4 samples (39) ; 10 km. W. of Ambo (8) ; 21 km. E. of Wolisso (2) ; tributaries of River Awash S. of Addis Ababa at Akaki, Dukem & Moggio (57). Sidamo : 17 and 30 km. S. of Adolla (70). Tigre : 0·5 km. S. of Adua on Gondar road (4). Wallaga : 22 km. W. of Guder on Lekemti road (22) ; 20 km. E. of Lekemti on Addis Ababa road (2). Wollo : 1 and 8·5 km. N. of Dessie (90).

Shell (pl. 3 ; 5 and 6, 10, 11)

The relationship between diameter and umbilicus diameter for part of a sample from 1 km. S. of Debra Berhan is shown in Text-fig. 29. The ratio D/UD ranges from 3·06 to 3·93, with a mean of 3·40 (20 shells).

The whorls are rounded in small shells, but the majority of medium and large specimens possess an angulation that is more or less acute and may bear a projecting fringe of periostracum. The angulation may be situated close to the underside of the shell, so that the lower surface is flattened, or nearer to the midline in which case the lower surface is rounded. In one sample (8 km. approx. N. of Dessie) the angulation is very slightly developed even in large specimens (pl. 3, 10 and 11). Transverse ribs of varying size are present, and may be covered with brown bands of periostracum. A very fine spiral sculpture is present in a few samples.

Four empty shells from Adowa (pl. 3, 5 and 6) have a rapidly widening whorl, and an acute angulation situated in the middle of the whorl. The height of the aperture is less than its width. A further specimen of this form, which resembles *Caillaudia angulata* Bourguignat, was obtained in Choa (59 km. N. of Addis Ababa, on the Debra Markos road).

Anatomy (Text-figs. 30, 31)

Some parts of the anatomy of *G. costulatus* have been previously described for specimens from Mozambique (Azevedo et al, 1957) and Angola (Wright, 1963a), but in neither of these accounts is the pneumostome region adequately described. In a well relaxed specimen (Text-fig. 30) the pulmonary siphon (PN) is a spout-like projection of the thickened ventral edge of the pneumostome, the left edge of which passes posteriorly for a short distance along the floor of the mantle cavity, overlying

the rectum as a short median rectal ridge (MED, following the terminology of Schutte & Van Eeden, 1959). The pseudobranch lobe bears a dorsal lamella (UL), that corresponds to that described by Schutte & Van Eeden, but, with the free edge lying on the right side of the pseudobranch lobe, its position is reversed compared to that in *Biomphalaria pfeifferi*. As a result of this, the anus (A), which opens near the base of the attachment of the dorsal lamella, is hidden by this lamella in *G. costulatus*. From the free margin of the dorsal lamella at the level of the anus, a ridge passes posteriorly and overlies the rectum as the lateral rectal ridge (RR).

The genital organs (Text-fig. 31) are similar to those of specimens from Angola and Mozambique, but not more than three lobes of the prostate gland are present even in large specimens (Wright records 9 in Angolan specimens). The penial stylet resembles that described by Wright.

Radula

In all of 5 radulae (9 km. approx. N. of Dessie) the cusps of unworn central teeth are not short and rounded as figured by Azevedo et al. Lateral teeth have three cusps and towards the 12th tooth in each transverse row an additional cusp is developed lateral to the ectocone. The upper part of the 12th tooth is relatively broad compared to that of the preceding teeth and the subsequent marginal teeth bear 5 or 6 cusps, among which that representing the mesocone of the lateral teeth is usually the biggest.

Remarks. Ethiopian *Gyraulus costulatus* can readily be distinguished from *Gyraulus* collected in Aden Protectorate and identified as *G. convexiusculus* Hutton by Wright (1963b). The whorl of the Aden specimens widens less rapidly than in *G. costulatus*, and the umbilicus is wider (Text-fig. 29) ; this difference in shell shape is reflected in the far more elongated genital system of *G. convexiusculus*.

There is considerable variation in shell shape but this does not lend itself to arrangement in subspecific categories as is possible for *G. costulatus* in Uganda and adjacent territories (Mandahl-Barth 1954). No Ethiopian specimens were collected from lakes which were the kind of habitat in which well defined forms were found by Mandahl-Barth.

A few specimens resembling *Caillaudia angulata* Bourguignat were obtained from two localities. As no other *Gyraulus* were found in these places, and no shells of similar shape are present in the other samples of *G. costulatus*, it is possible that Bourguignat's species is distinct from *G. costulatus*. The anatomy of the single living specimen that was obtained is similar to that of *G. costulatus*. *G. angulata* was described from one of Jickeli's figured specimens of *Planorbis costulatus* var. (Pl. 7, fig. 22), the other of which (pl. 7, fig. 23) was named *P. aethiopicus* by Bourguignat who considered it to be strikingly different to *P. costulatus* of Krauss. Krauss figured a shell that is unusually flattened with a carination and coarse ribs, whereas Jickeli's specimen is relatively thick with an almost evenly rounded whorl and finer ribs. The synonymy of the Ethiopian forms with *G. costulatus* cannot be established with certainty until large samples are examined from near the type locality in Natal.

Planorbis abyssinicus Jickeli is listed as a subspecies of *G. costulatus* by Bacci (1951), but careful examination of the description and figure of the shell shows that the species resembles *Anisus natalensis* far more closely.

Planorbis ehrenbergi Beck (=*P. cornu* Ehrenberg, nom. nud.) is recorded from near Addis Ababa by Neuville & Anthony (1908) with some reservation. This species appears to be a *Gyraulus* and is otherwise known from the Egyptian Nile. The shell (Roth, 1856, pl. 2, figs. 6–9) is not angulated, and the aperture is relatively rounded in a manner very similar to the specimen illustrated in pl. 3 (figs. 10, 11) of the present paper. If this is a valid species, it is likely as Neuville & Anthony remark, that it does occur in Ethiopia. The present specimens are referred to *G. costulatus*, pending the clearer definition of the forms of *Gyraulus* occurring in Africa, on both conchological and anatomical grounds.

Distribution. *G. costulatus* is widely distributed in Ethiopia and is often abundant in small slow-flowing waters ; a population was found at an altitude of 2,800 m. (9,150 ft.). Further south in Africa this species has an extensive range that includes Natal and the Congo.

LENTORBIS Mandahl-Barth

Lentorbis junodi (Connolly)

Hippeutis junodi Conolly, 1922 : 121 ; *Segmentina* (*Hippeutis*) *junodi* Conolly, 1925 : 200, pl. 4, fig. 30 ; *Lentorbis junodi ;* Mandahl-Barth, 1954.

Locality. Choa : 62 km. S. of Kombolchia (18).

Shell

The shells closely resemble the type series (B.M.N.H.) of which two specimens are illustrated by Wright (1963a), and conform to descriptions given by Mandahl-Barth (1954) and Azevedo et al (1961). In all the shells there is a spiral microsculpture of fine wavy lines which are much finer than the longitudinal striations mentioned by Azevedo et al (loc. cit.). The colour has been described by previous authors as red-brown to light orange, but the present specimens are very pale horn coloured, or almost colourless.

Largest specimen : D=4·2 mm.; H=1·6 mm.; $4\frac{1}{2}$ whorls.

Anatomy (Text-figs. 32)

The structure and arrangement of the genital organs (Text-fig. 32) agrees with the description given by Mandahl-Barth (1954), except in respect of the prostate gland which bears a larger number of lobes (18 instead of 12) in the present material, the spermatheca which has a long instead of a short duct, and the penis which is not coiled in the upper part of the sheath. As described by Azevedo et al (loc. cit.) the lobes of the prostate appear to open into a separate prostatic duct, and the vas deferens opens at the tip of the penis. The ovotestis consists of approximately 20 acini arranged in two alternating rows.

Remarks. There is a close resemblance between the type series of *L. junodi* and two of the original specimens of *L. benguelensis* (Dunker) apart from the presence of traces of septa in *junodi* already noted by Wright (1963a). This author con-

trasted the copulatory organ of his specimens of *L. benguelensis*, in which the sheath and preputium are nearly equal in length and width, with the copulatory organ of *L. junodi* in which the sheath is about twice as long and narrower than the preputium according to Azevedo et al (1961). These authors account of the copulatory organ of *L. junodi* is confirmed in the present specimens, but further anatomical study is desirable to establish the distinctness of these two species with certainty.

Distribution. *Lentorbis* does not appear to have been previously recorded from Ethiopia. Mandahl-Barth (1954) drew attention to the great distance separating *L. junodi* in Uganda from the previously known range confined to Mozambique, and it seems likely that the apparently discontinuous range of *Lentorbis* merely reflects the ease with which specimens are overlooked.

SEGMENTORBIS Mandahl-Barth

Segmentorbis (Segmentorbis) angustus (Jickeli)

Segmentina angusta Jickeli, 1874 : 220, pl. 7, fig. 24 ; *Segmentina angusta? ;* Blair in Ayad, 1956 ; *Segmentorbis angustus ;* Mandahl-Barth, 1954.

Localities. Arussi : Lake Zwai, N.W. shore (1). Choa : 64 km. S. of Kombolchia on Addis Ababa road (1). Eritrea : 15 km. N.W. of Asmara on Cheren road (4) ; River Toquor near Mekerka village (4). Kaffa : 22 km. approx. W. of Assendabo on Jimma road (2) ; 34 km. N. of Jimma on Agarro road (2).

Shell

Two sets of septa are present in all the specimens obtained from the type locality (River Toquor, near Mekerka), and there are traces of a third set in one shell. Up to five basal septa are present in shells from other localities. All the specimens from near Mekerka have the centre of the upper surface slightly depressed, but in the specimen from Lake Zwai this surface is flat. Spiral sculpture that is finer and less regular than that of *L. junodi* is present on some shells.

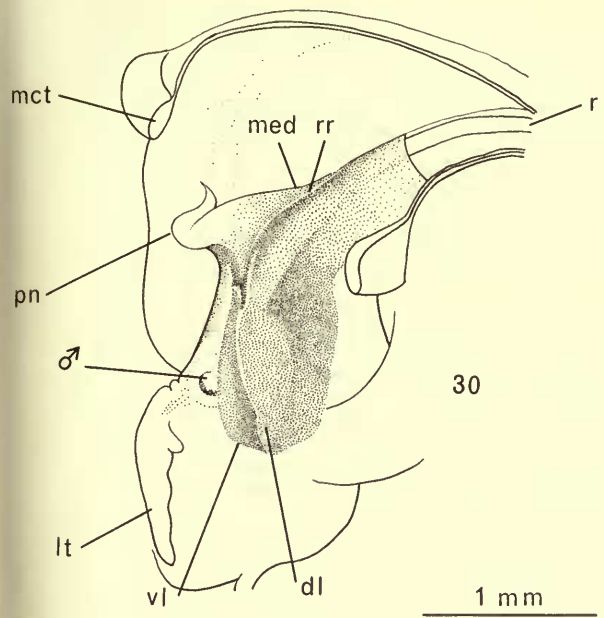
Largest shell : Lake Zwai) D=5·0 mm.; H=1·7 mm.; $4\frac{3}{4}$ whorls.

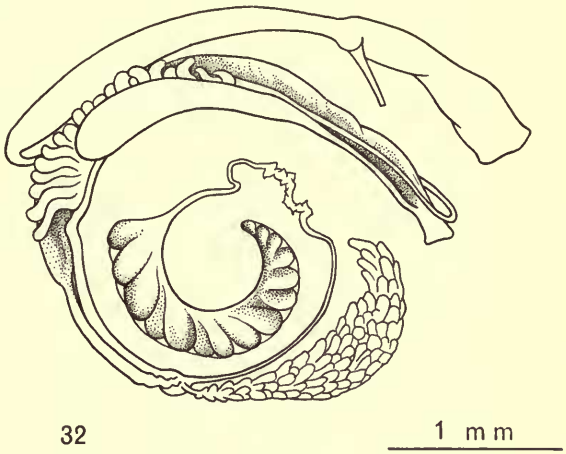
Anatomy (Text-fig. 33)

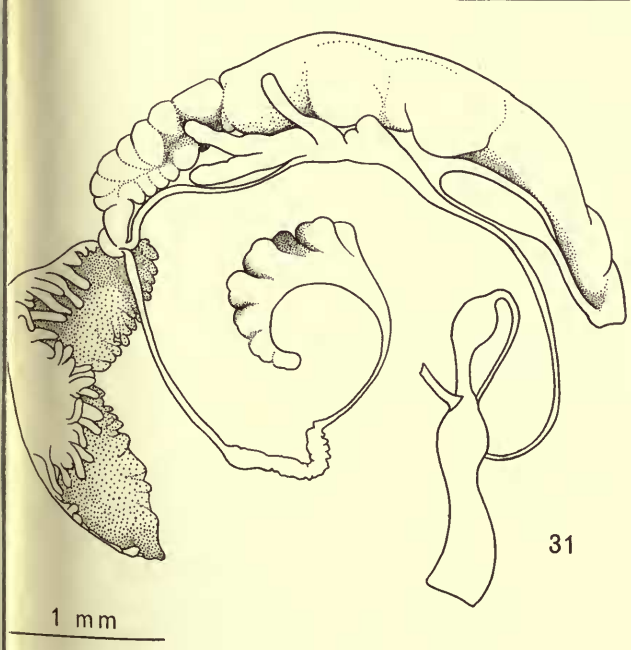
The pneumostome region is similar to that of *L. junodi* with the anus opening at the left edge of an anal lobe that lacks ridges.

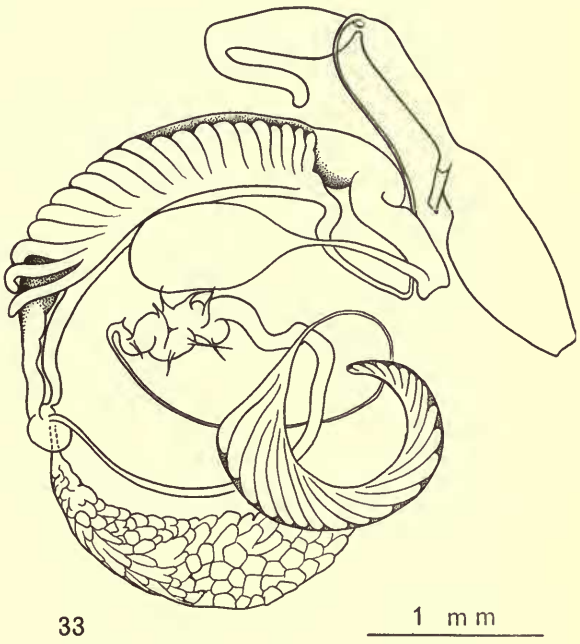
The genital organs of a specimen from the type locality are illustrated in Text-fig. 33. There are between 20 and 30 slender acini, arranged in two alternating rows, composing the ovotestis. An extremely thin part of the hermaphrodite duct precedes the seminal vesicle region, which is large in comparison to that of *L. junodi*, and bears filamentous processes. Similar genital organs are present in a specimen from Kaffa Province, which has even longer filamentous processes from the seminal vesicle region and about 40 acini in the ovotestis.

Remarks. There is a close resemblance between the shells of specimens from near Mekerka and those described by Jickeli, and although this author does not mention internal septa in his description, at least one septum is visible on the basal surface near the aperture in pl. 7, fig. 24c. Between 1 and 5 sets of septa have been recorded in specimens of *S. angustus* from Uganda (Mandahl-Barth, 1954) and Mozambique (Azevedo et al. 1961).









FIGS. 30, 31. *Gyraulus costulatus* from 1 km. S. of Debra Berhan. Fig. 30. Anterior part of animal viewed from left side, mantle cut on left side and raised to expose pulmonary siphon and pseudobranch. Fig. 31. Genital organs.

FIG. 32. *Lentorbis junodi* from 62 km. S. of Kombolchia, genital organs. FIG. 33. *Segmentorbis angustus* from River Toquor near Mekerka, genital organs.

According to these authors the duct of the spermatheca is approximately four times as long as the sac. The kind of spermatheca present in Ethiopian specimens is described by Mandahl-Barth for *S. planodiscus* (Melville & Ponsonby). However, as noted by this author, the sexual condition of the individual snail may effect the shape of the spermatheca and it is possible that the same factor accounts for the differences between the present specimens and those described by Azevedo et al (loc. cit.). These differences lie in the number of acini in the ovotestis, the number and arrangement of the lobes in the prostate (only four 3-branched lobes were observed in material from Mozambique), and the greater size of the seminal vesicle region in the Ethiopian specimens.

Distribution. Like the preceding species, *S. angustus* is easily overlooked, and is probably more widely distributed and abundant in Ethiopia than the records indicate. The species has a wide distribution in Africa, extending at least as far south as Mozambique.

Segmentorbis (Acutorbis) kanisaensis (Preston)

Segmentina kanisaensis Preston, 1914 : 265, pl. 18, figs. 17–19 ; *Segmentorbis kanisaensis ;* Mandahl-Barth, 1954.

Locality. Choa : 62 km. S. of Kombolchia (1).

Remarks. The occurrence of this species in Ethiopia is to be expected as it was originally described from the Nile at Kanisa and has a wide range extending to Natal (Connolly, 1939) and Angola (Wright, 1963a).

BIOMPHALARIA Preston

Biomphalaria sudanica species group

Biomphalaria sudanica (Martens)

Planorbis sudanicus Martens, 1870 : 35.
Planorbula alexandrina (non *Planorbis alexandrinus* Ehrenberg, 1831) Pilsbry & Bequaert, 1927 : 131.
Afroplanorbis boissyi tanganikanus (Bourguignat, 1888) Bacci, 1941.
Planorbis bozasi De Rochebrune & Germain, 1904 a : 141 ; 1904 b : pl. 1, figs. 2–4.
Planorbis abyssinicus (non *Planorbis abyssinicus* Jickeli, 1874) Piersanti, 1941 : fig. 37.

Localities. Arussi : Lake Zwai, N.W. shore (78) ; Lake Abyata, E. shore (15)*. Sidamo : Lake Awasa, E. shore (2)* ; Lake Margherita, E. shore (34).

Shell (Pl. 3, figs. 7–9, 12–14, Text-fig. 34)

The shells from Lakes Zwai, Awasa and Margherita have a flattened upper surface with a blunt angulation at the periphery. Beneath the angulation the surface of the whorl is more or less flattened, and there is a basal angulation close to the suture. The aperture is markedly asymmetrical in outline, being wider than it is high in the majority of specimens. The range and mean of ratio UD/H for shells between 9·0 and 10·9 mm. diameter are shown in Text-fig. 34. Coarse irregular transverse ridges are present, and where these are crossed by spiral grooves a nodular microsculpture is formed.

Largest shell (Lake Zwai) : D=15 mm.; UD=5·7 mm.; H=4·7 mm. ; $5\frac{1}{2}$ whorls. (Lake Abyata) : D=11·8 mm.; UD=3·74 mm.; H=4·4 mm.; $5\frac{1}{2}+$ whorls.

In the Lake Abyata specimens (pl. 3, figs. 12–14) the upper surface of the shell is slightly curved and the peripheral angulation is not so sharp. The width of the whorl does not increase so rapidly, the shape in cross section is almost symmetrical, so that the aperture is relatively small and almost as high as it is wide. The range and mean of ratio UD/H are included in Text-fig. 34.

Anatomy

Animals were obtained only from Lakes Zwai and Margherita. The penis sheath is a little longer or shorter than the preputium ; PS/PP in 10 specimens from Lake Zwai ranges from 0·78–1·04 mm.

Radula

The cusps of the lateral teeth are triangular (Lake Awasa, 12 radulae), or somewhat arrow-head shaped (Lake Margherita, 1 radula). In marginal teeth where the ectocone is present it is usually a single cusp, but this may have a serrated edge and up to three small cusps have been observed.

Remarks. It will be seen in Text-fig. 34 that although the three samples of *B. sudanica* lie at the upper limit of the variation of UD/H, there is no marked discontinuity from the series of samples of *B. pfeifferi rueppelli*, one of which (No. 26) has a greater mean ratio UD/H than the sample of *B. sudanica* from Lake Abyata (No. 25). A large number of radulae are available only for *B. sudanica* from Lake Zwai, and although a single ectocone cusp is more frequently present on the marginal teeth in these specimens, there are no consistent differences to the radulae of the population of *rueppelli* mentioned above, or another (No. 24) which also has a high mean ratio UD/H. Both these populations are from near the floor of the Rift Valley close to the River Awash, so that although in general appearance they resemble the plateau form of *rueppelli*, it is possible that some genetic exchange has taken place with the lake populations of *B. sudanica*.

Pilsbry & Bequaert (1927, p. 131) state that they have seen specimens of *Planorbula alexandrina* from Lake Abaja (Lake Margherita), and it is of interest that the radula of a specimen from this lake has cusps approaching the arrow-head shapecharacteristic of the *Biomphalaria alexandrina* species group (Mandahl-Barth, 1957a). The copulatory organ resembles that of *B. sudanica*, having the penis sheath shorter or not much longer than the preputium.

Planorbis bozasi described from Lake Shala closely resembles *B. sudanica* from Lake Zwai. No *Biomphalaria* were found in Lake Shala during the recent expedition and it is unlikely that living molluscs occur in the lake at the present time because of the high alkalinity.

It is evident from the figure and the dimensions (diameter=14·5 mm.) that "*Planorbis abyssinicus*" recorded by Piersanti from Lake Stephanie is not Jickeli's species, which resembles *Anisus natalensis*, but is probably *B. sudanica*.

Distribution. *Biomphalaria sudanica* is restricted to certain lakes in the southern part of the Ethiopian Rift Valley ; it occurs in Sudan, Uganda, Congo and N. Rhodesia, and has recently been found in Ghana (Mandahl-Barth, pers. comm.).

Biomphalaria pfeifferi species group

Biomphalaria pfeifferi rueppelli (Dunker)

Planorbis rüppellii Dunker, 1848 : 42 ; Martini & Chemnitz, 1856 : 41, pl. 5, figs. 10–12 ; Martens, 1869 ; Blanford, 1870 ; Morelet, 1872 ; Jickeli, 1874 ; Nevill, 1878 ; Bourguignat, 1883 ; Pollonera, 1898 ; De Rochebrune & Germain, 1904 ; Neuville & Anthony, 1908 ; Connolly, 1928 ; Giovannola, 1939 ; *Planorbis* (*Biomphalaria*) *rüppellii ;* Piersanti, 1940 ; Piersanti, 1941 ; *Biomphalaria rüppellii ;* Mandahl-Barth in Ayad, 1956 ; *Biomphalaria rueppelli ;* Wright & Brown, 1962.

Planorbula alexandrina (non *Planorbis alexandrinus* Ehrenberg, 1831) Pollonera, 1898 : 11.

Planorbis biossyi (non *Planorbis biossyi* Potiez & Michaud, 1838) Jickeli, 1874 : 213 ; Pollonera, 1898 : 11 ; Giovannola, 1937 : 158 ; *Planorbis biossyi* var. *asmarica* Satta, 1936 : 193.

Planorbis adowensis Bourguignat, 1879 : 11 ; 1888 : pl. 1, figs. 1–4 ; Germain 1904 ; Neuville & Anthony, 1906 ; Germain, 1921 ; Giovannola, 1939 ; *Planorbis herbini* var. *adowensis ;* Pollonera, 1898 ; *Biomphalaria adowensis ;* Bacci, 1941.

Planorbis herbini Bourguignat, 1883 : 101 (Jickeli, 1874 : pl. 7, fig. 18) ; Pollonera, 1898 ; Germain, 1904 ; Connolly, 1928.

Planorbis cecchii Pollonera, 1887 : 2.

Planorbis bridouxi (non *Planorbis bridouxianus* Bourguignat, 1890) Neuville & Anthony, 1908 : 253, fig. 2 ; Germain, 1931 : 366.

Planorbula boccardi Pollonera, 1898 : 11, figs. 22–25.

Localities. Arussi : 5 km. approx. S. of Adamitullo near Bulbulla River (1)* ; River Awash S. of Nazareth (5) ; 1 km. S. of River Awash on Asella Road (150). Begemeder : 3 and 8 km. N. of Gorgora on Gondar Road (14) ; 5 and 66 km. N. of Gondar on Asmara road (24) ; 1, 14 and 115 km. N. of Medhamie Alem on Asmara road (115). Choa : Lake Hora (23)* ; Lake Bishoftu (10) ; S. of Akaki (80) ; N. of Dukem, 2 samples (135) ; Awash river on Addis Ababa–Wolisso road (60) ; 21 km. E. and 30 km. W. of Wolisso (65) ; 1–10 km. W. of Ambo, 4 samples (300) ; 32–177 km. N. of Addis Ababa on Debra Markos road, 5 samples (460) ; 11–51 km. N. of Addis Ababa on Asmara road, 4 samples (540) ; 222 (Robi village) and 264 km. N. of Addis Ababa on Asmara road (250) ; 98 km. N. of Robi village on Asmara road (52). Eritrea : 22–83 km. S. of Asmara on Gondar road, 6 samples (280) ; 2 km. W. of Adi Ugri on Arezza road (8) ; 3 km. E. of Teramni on Decamere road (6) ; 66 and 70 km. S. of Asmara on Addis Ababa road (225) ; River Toquor near Mekerka village (214). Harar : 10 km. W. of Harar on Dire Dawa road (110) ; 9 km. E. of Harar on Jijiga road (38) ; 8 km. E. of Aramyia village (8) ; 46 km. on Carsa road from junction with Dire Dawa–Harar road (300) and 3 km. approx. W. of junction (10). Kaffa : 9 km. W. of Kombi–22 km. W. of Assendabo on Addis Ababa–Jimma road, 8 samples (180) ; 4 and 14 km. W. of Jimma on Bonga road (190) ; 34 and 38 km. N. of Jimma on Agarro road (130). Sidamo : Storage dams at Neghelli, 3 samples (238). Tigre : 0·5 km. S. of Adowa on Gondar road (180)*; 222 km. S. of Asmara on Addis Ababa road (7). Wallaga : 9 km. W. of Guder on Lekemti road (8). Wallo : 1 km. within N. boundary of Dessie on Asmara road and 30 km. N. of town (280) ; 0·5 km. W. of Kombolchia on Dessie road (14) ; 10 km. approx. E. of Kombolchia on Batei road (400) ; 1 km. W. of Batei N. of Kombolchia road (169) ; 26 km. S. of Kombolchia on Addis Ababa road (30).

Shell

The shells are generally thicker, with a narrower umbilicus and less flattened upper surface than in *B. sudanica*. The largest specimen is 15·8 mm. in diameter and consists of $4\frac{7}{8}$ whorls, i.e. approximately one whorl less than in a *sudanica* shell of the same size. A spiral microsculpture consisting of rows of short ridges and nodules is present on the lower and upper surfaces of some specimens in the majority of samples. The relationship between D, UD, and H was found to vary in the same sample with the size of the shell, i.e., UD/H tended to increase with D as in two samples from near Debra Markos, Gojjam Province, described by Wright & Brown (1962). The mean and range of the ratio UD/H for 25 samples is shown in Text-fig. 34 ; a limited size group of D has been selected in order to minimise the effect of variance of UD/H with D, on the variance between different samples.

Anatomy

Some details of the gross anatomy of *B. pfeifferi rueppelli* are given by Wright & Brown (loc. cit.), and the only difference observed in the present material is that the internal muscle pillars of the preputium are variable in their relative size instead of being constantly asymmetrical.

The proportions of the copulatory organ of a sample from 10 km. W. of Harar (Text-fig. 34, 3) with a narrowly umbilicate shell are : mean PS/PP = 0·83 ; range 0·59–1·00 (10 specimens). In a samples from 34 km. N. of Jimma (Text-fig. 34, 23) with a widely umbilicate shell : mean PS/PP = 0·80 ; range 0·73–1·16 (10 specimens).

Radula

As was the case in specimens from near Debra Markos the degree of subdivision of the ectocone of the marginal teeth (mistakenly called lateral teeth, Wright & Brown loc. cit., p. 297, l. 34) is variable. Four cusps are present in 4 out of 15 radulae examined, but in 13 radulae at least some marginal teeth have an undivided ectocone.

Remarks. There are such conspicuous differences in shell shape between many of the populations of *B. pfeifferi rueppelli* in Ethiopia that the existence of many synonymous records is not surprising. The range of variation of UD/H (Text-fig. 34) of several samples overlaps only slightly or not at all, but there is a more or less continuous variation in the mean ratio UD/H between the most narrowly and the most widely umbilicate populations. No differences have yet been observed in the anatomy or radulae of samples representing the extreme limits of this variation, and there appears to be no justification for recognising more than a single form of the *B. pfeifferi* group in the plateau region of Ethiopia. Mandahl-Barth (1960) has proposed that the use of subspecies in this group should be abandoned, but it seems useful to retain a subspecific category *rueppelli* for the *B. pfeifferi* of the Ethiopian Plateau (and possibly also the Arabian Peninsula), where a higher proportion of narrowly umbilicate populations reaching a small maximum size seems to occur in comparison to the rest of the range of the species.

After examining the original specimens, Bacci (1943) concluded that *Planorbula alexandrina* and *P. boccardi* recorded from Eritrea by Pollonera were not significantly different. The figures of the latter species represent a frequently occurring form of

rueppelli. It is highly probable that the two single shells of *P. boissyi* recorded by Jickeli and Pollonera are relatively widely umbilicate shells of *rueppelli*, to which species Giovannola (1939) refers his own record (1937) of *P. boissyi* and that of Satta. As pointed out by Mandahl-Barth (1957a), *P. herbini* and *P. cecchii* are probably narrowly umbilicate and juvenile shells respectively of *rueppelli*, but with regard to the occurrence of *B. sudanica* in the Rift Valley of Ethiopia it now appears that *P. bozasi* belongs to this species. The specimens of *P. bridouxi* illustrated by Neuville & Anthony represent a narrowly umbilicate *rueppelli* with a widely flared aperture.

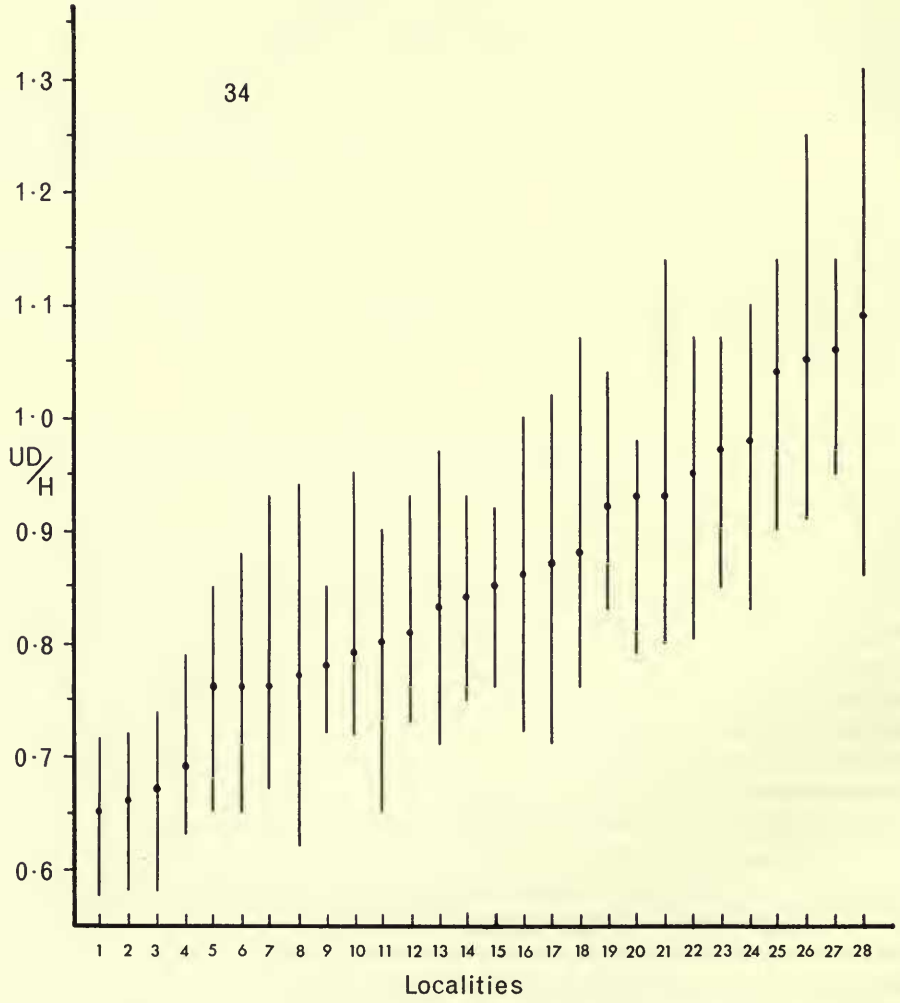


FIG. 34. Range and mean of the ratio UD/H (umbilicus diameter/height) of *Biomphalaria* shells between 9·0 and 10·9 mm. diameter. Localities 1–24 and 26 *B. pfeifferi rueppelli*, 25, 27 and 28 *B. sudanica*.

List of localities

1. Eritrea ; 32 km. W. of Asmara on Cheren road.
2. Choa ; Lake Hora.
3. Harar ; 10 km. W. of Harar.
4. Tigre ; 0·5 km. S. of Adowa.
5. Wallo ; 1 km. N. of Dessie boundary.
6. Harar ; 46 km. on Carsa road.
7. Eritrea ; 83 km. S. of Asmara on Gondar road.
8. Eritrea ; River Toquor near Mekerka.
9. Choa ; 32 km. N. of Addis Ababa on Debra Markos road.
10. Eritrea ; 101 km. S. of Asmara on Addis Ababa road.
11. Eritrea ; 39 km. S. of Asmara on Gondar road.
12. Harar ; 9 km. E. of Harar.
13. Choa ; 35 km. N. of Addis Ababa on Asmara road.
14. Choa ; 10 km. W of Ambo on Lekemti road.
15. Kaffa ; 26 km. W. of Sokuru on Jimma road.
16. Sidamo ; army barracks Neghelli.
17. Choa ; 59 km. N. of Addis Ababa on Debra Markos road.
18. Choa ; 4 km. W. of Ambo on Lekemti road.
19. Choa; 42 km. N. of Robi on Asmara road.
20. Kaffa ; 9 km. W. of Assendabo on Jimma road.
21. Begemeder ; 1 km. N. of Medhanie Alem on Asmara road.
22. Begemeder ; 14 km. N. of Medhanie Alem on Asmara road.
23. Kaffa ; 34 km. N. of Jimma on Agarro road.
24. Choa ; outflow below Koka Dam.
25. Arussi ; Lake Abyata.
26. Arussi ; 1 km. S. of River Awash on Asella road.
27. Sidamo ; Lake Margherita.
28. Arussi ; Lake Zwai.

Particular attention must be given to *P. adowensis* as this form has been frequently discussed in the literature. Bourguignat states (1883, p. 101) that *P. adowensis* is " remarquable par sa forme globuleuse, et par la rapidité de sa croissance spirale ", but the specimen illustrated (1888) from Lake Tanganyika shows these characteristics to a lesser degree than does the shell illustrated as *P. bridouxianus*, which closely resembles the specimens from near Adowa in the present collection and that illustrated by Mandahl-Barth (1957a). Germain (1904) accepts that both *bridouxianus* and *adowensis* are narrowly umbilicate forms, traces a continuous gradation between *sudanica* and *bridouxianus*, and suggests geographical ranges for some of the intermediate forms. Giovannola (1939) also finds a geographical pattern in distribution of shell shape, contrasting *B. rueppelli* of Eritrea with the relatively narrowly umbilicate *P. adowensis* occurring in the vicinity of Harar. However, Neuville & Anthony (1908) do not recognise *adowensis* as a distinct species and draw attention to the great variation occurring in a limited area and the existence of mixed populations. The present collection supports this view, also held by Mandahl-Barth (loc. cit.), that there is no clear geographical separation in the ranges of the two forms, and it appears likely that narrowly umbilicate shells occur in all parts of the range of *B. pf. rueppelli*. It is also evident that when a large number of populations are considered there is a gradation between the extremes of shell shape. However, individual populations may exhibit only a limited part of the range of shell shape,

and this may also be so in groups of populations, as shown by the present samples from near Harar which are all relatively narrowly umbilicate as was observed by Giovannola. Specimens of " *adowensis* " from near Adowa were found to have the penis sheath much shorter than that of *rueppelli* by Mandahl-Barth. No marked difference was found between the copulatory organs of two samples representing the extremes of shell shape in the present collection (see Anatomy, above).

Distribution. The range of *B. pfeifferi* extends over most of Africa south of the Sahara ; *B. rueppelli* has been recorded from many parts of this range outside Ethiopia but it is here concluded that only the *Biomphalaria* of the Ethiopian plateau, possibly together with those of the Arabian Peninsula, merit recognition as the subspecies *B. pfeifferi rueppelli*.

Family **FERRISSIIDAE**

BURNUPIA Walker

Burnupia caffra (Krauss)

Ancylus caffer Krauss, 1848 : 70, pl. 4, fig. 13 ; *Burnupia caffra ;* Walker, 1923 ; *Burnupia sp.* cf. *caffra ;* Brown, 1961.
Burnupia (*? abyssinica* Jickeli) ; Mandahl-Barth in Ayad, 1956.

Localities. Begemeder : 8 km. N. of Gorgora (30). Choa : 11 km. and 67 km. N. of Addis Ababa on Asmara road (47) ; 36 km. and 59 km. N. of Addis Ababa on Debra Markos road (12) ; 32 km. W. of Wolisso (2). Sidamo ; 17 km. and 30 km. S. of Adolla (45).

Shell

The shells resemble a small sample from Addis Ababa (Brown, 1961), in possessing a well developed apex that is turned to the right and situated in the posterior third of the shell. Shell shape varies considerably in the larger samples that have now been obtained ; the extreme values of the ratio H/L in the sample from Begemeder are 0·38 and 0·48. The shape of the shell base also varies within samples, it may be an evenly rounded broad oval, or narrow and irregularly flattened. Radial sculpture may be hardly detectable and confined to the edge of the shell, or well developed over much of the surface and visible at a relatively low magnification (× 10).

Anatomy (Text-fig. 16)

The pseudobranch (fig. 16) is divided into basal and upper lamellae, each of which may be folded transversely. The rectum passes through the posterior part of the basal lamella and the anus is not covered by the upper lamella.

The genital organs are similar to those described by Brown (1961). Characteristic features are, the few large lobes of the ovotestis, the absence of protuberances on the seminal vesicle region of the hermaphrodite duct, and the long lobes of the prostate gland. Larger specimens than those previously available have now been dissected. Up to 11 terminal lobes are present in the ovotestis (8 were previously described), and

two additional lobes are sometimes present in the prostate gland giving a total of 10 terminal lobes. A dilatation of the vas deferens, preceding the junction with the penis sheath, has been observed in all specimens. All of 20 specimens dissected are euphallic.

The "carrefour" Brown (loc. cit.) situated at the base of the albumen gland duct proximal to the junction between the hermaphrodite duct, uterus and vas deferens, appears to correspond to the "fertilisation sac" in *Ancylus fluviatilis* (Duncan, 1960).

Radula (Text-fig. 37)

The central teeth are bicuspid. Inner lateral teeth have three large cusps and a small additional lateral cusp that increases in size towards the radula margin. Marginal teeth bear up to six small sharp cusps.

A radula from the Begemeder sample is unusual (Text-fig. 37) in having asymmetrical cusps on the central tooth, relatively large additional ectocones on the lateral teeth and bicuspid endocones on the first lateral teeth of one side. Grooves on the endocones of the lateral teeth are particularly marked in all the radulae seen of this sample.

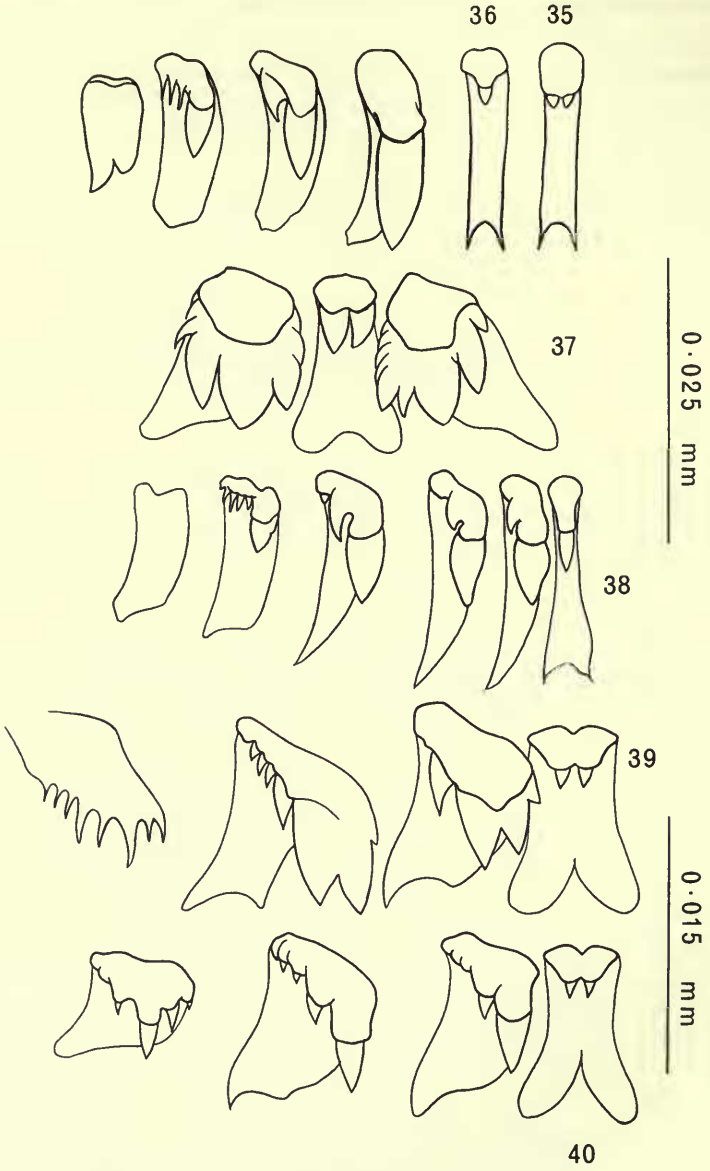
Remarks. In the larger samples the extent of variation is such that selected shells from each sample could be considered to belong to different species. As it is likely that many of the existing specific diagnoses within the genus *Burnupia* are founded on trivial differences in shell shape and ornamentation, the *Burnupia* in this collection are regarded as a single form.

Connolly (1939) gives the range of *B. caffra* as Natal and Cape Province, and the species is recorded from the Congo by Pilsbry and Bequaert (1927). The occurrence of similar specimens in Ethiopia suggests that *B. caffra* has a very wide range in Africa. It is also likely, considering the variation present in the Ethiopian samples, that the mixed populations mentioned by Pilsbry & Bequaert containing *B. caffra* and other species of *Burnupia* were composed of only a single form. However, it is remarkable that shells similar to *caffra* have not been found in East Africa ; specimens figured by Mandahl-Barth (1954) as *B. stuhlmanni* (Martens, 1897), and *B. crassistriata* (Preston, 1911), differ clearly from the Ethiopian specimens, as do the paratypes of *B. kempi* (Preston, 1912, B.M.N.H.).

Two species of *Ancylus* described by Jickeli (1874) from a locality near Asmara, Eritrea, have been regarded as closely related to *Ancylus fluviatilis* (Müller) by Walker (1914), but Mandahl-Barth (in Ayad, 1956) raises the question that one of these species may be *Burnupia* by identifying specimens from near Asmara and Addis Ababa as *Burnupia ? abyssinica* (Jickeli). This record was unfortunately overlooked by Brown (1961) but Dr. Mandahl-Barth now considers that these specimens are "true *Ancylus*" (in litt.). As the specimens figured by Jickeli have the apex turned to the right far less acutely than do any Ethiopian *Burnupia*, and as no specimens of this genus were found in Eritrea during the recent expedition it is almost certain that Jickeli's species is not a *Burnupia*.

Distribution. *B. caffra* appears to have a widespread range on the Ethiopian plateau N.W. of the Rift Valley, and also occurs at similar altitudes on the S.E. side of this valley. This species does not appear to have been recorded from the

surrounding parts of N.E. Africa, but it probably has an extensive range as it was originally described from Natal and has been recorded in the Congo.



FIGS. 35–40. Radula teeth. Figs. 35, 36. *Ancylus fluviatilis*. Fig. 35. 10 km. N. of Debra. Berhan, central. Fig. 36. River Toquor near Mekerka, central, 3, 29, 31 and 38. Fig. 37. *Burnupia caffra* from 8 km. N. of Gorgora, 1, central, 1. Fig. 38. *Ancylus* sp. from 15 km. N. of Dilla, central, 1, 3, 14, 23 and 27. Fig. 39. *Ferrissia clessiniana* ? from 17 km. S. of Adolla, central, 1, 8 and 16. Fig. 40. *Ferrissia isseli* ? from 89 km. W. of Guder, central, 1, 8 and 16.

FERRISSIA Walker[1]

Ferrissia clessiniana (Jickeli)?

Ancylus clessinianus Jickeli, 1882 : 366 ; *Ferrissia clessiniana ;* Walker, 1914 : figs. 9–11.
Ancylus sp. Blanford, 1870.

Localities. Arussi : 55 km. S. of River Awash on Asella road (45). Choa : 93 km. W. of Addis Ababa on Jimma road (1). Harar : 46 km. on Carsa road from Junction with Dire Dawa–Harar road (12). Sidamo : 4 km. S. of Wondo on Dilla road (30) ; 60 km. S. of Argereselam on Neghelli road (2) ; 17 km. S. of Adolla on Neghelli road (20).

Shell

The outline of the base is relatively narrow, wider in front than behind and more or less straight-sided (Text-figs. 46, 47). In one sample from Sidamo (S. of River Awash on Asella road) there is a gradation between this shape and an irregular oval outline. The apex is situated to the right of the longitudinal axis at about two-thirds of the longest dimension from the anterior margin ; in 10 shells this distance varies between 0·66 and 0·75 of the total length. The anterior surface is convex and the posterior surface concave ; the sides are almost flat and concave near the margin. Radial sculpture is absent except on the apex, where fine ribs are visible at a magnification of ×50. None of the specimens has a septum.

In two of the samples an unusually large size for *Ferrissia* in Africa is reached.

Largest shell (Sidamo, 17 km. S. of Adolla) : 4·3 mm. ; W = 2·5 mm. ; H = 1·2 mm. Sidamo : S. of River Awash : L = 5·2 mm. ; W = 3·7 mm. ; H = 1·7 mm.

Anatomy

All 10 specimens dissected are aphallic.

Radula (Text-fig. 39)

The central tooth is bicuspid. Three or four cusps are present on the median lateral teeth, and additional small cusps are developed on the lateral sides of the teeth towards the margin of the radula. The marginal teeth bear about 8 slender cusps that are nearly equal in size.

Remarks. Four specimens recorded as *Ancylus sp.* by Blanford from near Mai Wahiz in Tigre Province appear to be the only *Ferrissia* previously collected in Ethiopia. Blanford compares these specimens to the Indian species *A. verruca* Benson, and they are considered to be a *Ferrissia* by Walker (1914) and Gwatkin (in Walker, loc. cit.).

The present specimens resemble *F. clessiniana* (Jickeli), originally described from near Alexandria, in the large individual maximum size and elongated basal outline ; other species of *Ferrissia* known to occur in Egypt (figured by Walker, loc. cit.) have a distinctly more rounded outline.

As all the specimens of *F. clessiniana?* were collected from submerged vegetation,

[1]The genus *Ferrissia* is here used in accordance with past usage, but it is probable that true *Ferrissia* do not occur in Africa (see Introduction).

including narrow stems and grasses, the possibility that their elongated shape may be partly due to the influence of the substratum should be considered. However, specimens collected by Dr. C. A. Wright at Tafwa, near Dhala (Western Aden Protectorate) from stones also have an elongated shape similar to that of *F. clessiniana*. There are consistent differences between the radulae of *F. clessiniana?* and the *Ferrissia* described below which has a rounded outline.

Distribution. *F. clessiniana?* appears to be widely distributed in the southern half of Ethiopia, occurring in streams containing thick vegetation.

Ferrissia isseli (Bourguignat)?

Ancylus isseli Bourguignat, 1866 : 214, pl. 33, figs. 13–18 ; *Ferrissia isseli ;* Walker, 1914.

Locality. Wallaga : 89 km. W. of Guder (22).

Shell (Text-fig. 45)

The outline of the base is ovate and more or less symmetrical, with the sides not straight for more than a short distance. The apex is blunt and rounded, situated slightly to the right of the longitudinal axis at about two-thirds of the longest dimension from the anterior margin. This distance varies in 10 shells between 0·64 and 0·73 of the total length. The anterior surface is gently convex and the posterior surface slightly concave or nearly straight. Lateral surfaces are slightly convex and not at all flared towards the margin as in the preceding species. Radial sculpture consists of very fine ribs confined to the apex. None of the specimens has a septum.

Largest shell : L = 3·2 mm. ; W = 2·3 mm. ; H = 1·5 mm.

Anatomy

All of the 10 specimens dissected are aphallic.

Radula (Text-fig. 40)

As in the preceding species the central tooth is bicuspid, but the shape of the upper parts of the lateral and marginal teeth, and the arrangement of the cusps is conspicuously different. The median side of the upper part of each lateral tooth is elongated and bears one large cusp (which may represent the fused ectocone and mesocone), that is set apart from the other cusps. There is relatively little change in the form of the teeth until close to the margin of the radula. Marginal teeth bear 4–5 widely spaced cusps of unequal size.

Remarks. The shells are relatively higher than those of the *Ferrissia* species described by Mandahl-Barth (1954), and resemble the shells from Alexandria identified as *F. isseli* and *F. pallaryi* by Walker (1914). As *F. pallaryi* was described from a sample of only three specimens, it is preferable to refer the Ethiopian specimens tentatively to the older name.

The broader basal outline of *F. isseli?* compared to that of *F. clessiniana?* could be attributed to the fact that all specimens of the former species were collected from stones. However, the radulae provide strong evidence that the two forms are distinct.

Family **ANCYLIDAE**

ANCYLUS Müller

Ancylus fluviatilis species group

Ancylus fluviatilis Müller

Ancylus fluviatilis Müller, 1774 : 201 ; Blanford, 1870.
Ancylus abyssinicus Jickeli, 1874 : 223, pl. 7, figs. 27 & 28 ; Bourguignat, 1883 ; Pollonera, 1898 ; De Rochebrune & Germain, 1904 ; *Pseudancylus abyssinicus ;* Connolly, 1941.
Ancylus hamacenicus Bourguignat, 1883 : 84, (= *A. compressus* Jickeli, nom. nud. 1874, pl. 7, fig. 26).

Localities. Begemeder : 5 km. and 45 km. N. of Gondar on Asmara road (6) and (78). Choa : 10 km. N. of Debra Berhan on Asmara road (4) ; 47 km. N. of Addis Ababa on Debra Markos road (2). Eritrea : 18 km. W. of Asmara on Cheren road (18) ; River Toquor near Mekerka village (55). Tigre : 222 km. S. of Asmara on Addis Ababa road (20).

Shell (Text-figs. 41–43)

There is great variation in the shape of the shell base, the relative proportions of length and height, and the shape of the apex. In a series of shells from the River Toquor near Mekerka, Eritrea (Text-fig. 41), the ratio W/L varies between 0·74 and 0·83, and H/L between 0·37 and 0·51. In the Tigre sample the apices are blunter, and one shell is almost circular in outline (Text-fig. 42). The shells from 30 km. N. of Gondar are characterised by very large curved apices, which overhang the posterior margin (Text-fig. 43).

The apex is sculptured with a variable number of radial ribs, that are coarse in comparison with those of the succeeding species. A few ribs (primary ribs) extend over the rim of the apical depression into the hollow of the depression, and additional ribs are developed in increasing numbers towards the periphery of the shell. On the apex primary ribs are usually larger than later formed ribs, but a short distance from the apex all ribs are of similar size, and near the periphery the radial sculpture consists of fine wavy ridges. In some shells the sculpture does not extend beyond the ridge marking the end of the first growth stage. Fine circular sculpture connects the primary ribs on the apex, and coarser more or less regular circular ridges are present on the rest of the shell surface. Shells differ in the number and relative size of the primary ribs, and in the rate at which later formed ribs are intercalated between them. In some shells approximately 40 ribs are present in the vicinity of the apical depression, but in others a smaller number (15 or less) of larger ribs is present. Each sample has a more or less distinctive type of radial sculpture ; both the extreme forms described above are present in the Mekerka sample, although the form with large primary ribs is the more frequent.

Anatomy (Text-fig. 15)

The pseudobranch contains deep transverse folds, one of which usually covers the anus (Text-fig. 15).

Apart from the presence of 5–6 lobes of the prostate gland instead of 3, the genital organs resemble those described by Lacaze-Duthiers (1899). Wright (1963b)

comments that in specimens from Aden the flagellum appears to have a separate opening into the preputium instead of opening into the penis sheath as described by Lacaze-Duthiers. This observation was based on a specimen in which the penis sheath was everted into the preputium ; in other Aden specimens that have been dissected the structure is like that described by Lacaze-Duthiers, as is also the case in Ethiopian specimens.

Radula (Text-figs. 35 and 36)

The central tooth usually bears one small cusp. Median lateral teeth bear a single large cusp, but an ectocone becomes progressively well developed towards the edge of the radula, and is sub-divided into 3 or 4 small cusps on the lateral edge of the marginal teeth. Cusps are absent from the outer marginal teeth. In one longitudinal row of marginal teeth an endocone is present, and in a radula of a specimen from 10 km. N. of Debra Berhan the central tooth bears two small cusps (Text-fig. 35). In certain specimens the cusp on the central tooth is extremely small, and this probably accounts for Jickeli's failure to find this cusp in *A. abyssinicus*. Wright (1963b) illustrates a bicuspid central tooth in *A. fluviatilis* from Aden.

Remarks. The extent of variation in shell shape in the series (55 specimens) from the River Toquor near Mekerka, suggests that *A. abyssinicus* Jickeli and *A. hamacenicus* Bourguignat, which were originally described from this locality, are synonymous. In view of the probability that the shape of ancylid shells is affected by the substratum on which they grow, the relatively narrow shape of *hamacenicus* may be a modification induced by growth on narrow plant stems. All of the original nine specimens of *hamacenicus* were found on vegetation hanging in the water, whereas *abyssinicus* was collected from stones.

Jickeli observed a close resemblance between small specimens of *A. abyssinicus* and *A. fluviatilis* from Europe, but recognised significant differences between fully grown shells, and in the radulae. Walker (1914) is of the opinion that both Jickeli's species are closely related to *A. fluviatilis*, but Connolly (1941) records *A. abyssinicus* from the Yemen as a distinct species. Wright (1963b) identifies further specimens from Western Aden Protectorate as *A. fluviatilis*, and refers both Connolly's records to this species.

The present collection contains a wide variety of *Ancylus* shells resembling *A. fluviatilis*, and it would be desirable to compare this variation in shell shape with that occurring in Europe, and to assess the significance of differences in conjunction with anatomical information. A detailed study of this kind is beyond the scope of the present work, but it appears that the differences described by Jickeli between *A. abyssinicus* and *A. fluviatilis* are not significant. Of the outstanding shell forms in the present collection, that with a large hooked apex (Text-fig. 43) is similar to the specimen of *A. pileolus* Fer. illustrated by Roth (1856, pl. 2), but the flattened rounded form (Text-fig. 42) does not appear to have been described in Europe.

It is likely that detailed study will reveal differences between *A. fluviatilis* in its European range and the isolated groups of populations in North Africa and the Arabian Peninsula which are probably remnants of a formerly more extensive range.

Two forms described below appear to be distinct from the populations included above in *A. fluviatilis*. It is possible that distinct African forms of *Ancylus* also exist in Algeria (Bourguignat, 1864).

Distribution. *A. fluviatilis* has an extensive range on the central and northern parts of the N.W. massif of the Ethiopian plateau ; the lowest altitude at which specimens were found was 2,240 m. (7,400 ft.). This species reaches the southern limit of its range in N. Africa and the Arabian Peninsula.

Ancylus sp.

Localities. Choa : 30 km. W. of Wolisso (55) ; 89 km. W. of Guder (22) ; 33 km. E. of Bako (62). Kaffa : 28 km. N. of Jimma on Agarro road (35). Sidamo : 15 km. N. of Dilla (27).

Shell (pl. 3, 17 and 18)

The outline is broadly oval with more or less evenly curved sides. The apex is depressed, and situated at about two thirds of the longest dimension from the anterior margin. In 10 shells from 30 km. W. of Wolisso this distance varies between 0·65 and 0·69 of the total length. The blunt apex is not at all hook-shaped apart form the slightly projecting posterior rim of the apical depression. The anterior surface is evenly curved, the posterior surface is more or less straight, except at the apex and near the margin. Radial sculpture is well defined only on the apex, where 60–80 fine ridges extend to near the apical depression. Circular sculpture consists of irregular fine ridges.

Largest shell : L = 7·0 mm. ; W = 5·7 mm. ; H = 2·7 mm. ; ratio H/W = 0·47.

Anatomy (Text-fig. 14)

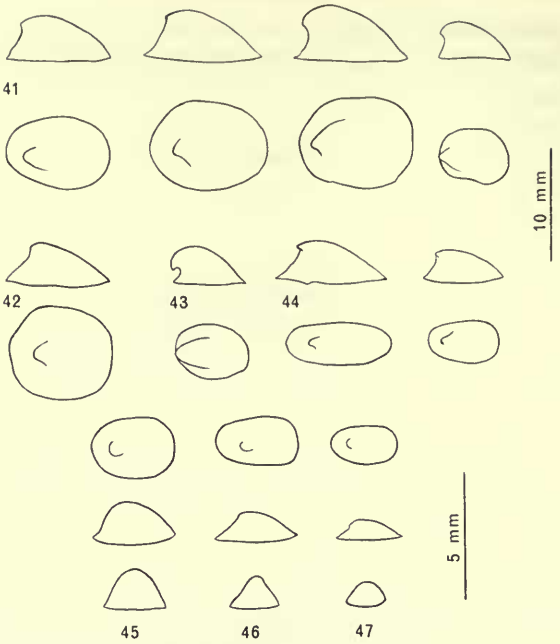
The pseudobranch is a simple lobe, with usually only a trace of the transverse folds that are better developed in *A. fluviatilis*. This appears to be a consistent difference between the two forms, but it must be borne in mind that the appearance of the pseudobranch depends very much on the degree of contraction of the organ. No significant differences have been observed between the genital systems of the two forms.

Radula (Text-fig. 38)

There appear to be differences to *A. fluviatilis* in the shape of both the upper and the basal parts of the teeth. The ectocone is relatively well developed on the first lateral tooth, and subdivision of the ectocone begins between the 18th and 20th teeth, instead of at about the 25th tooth in a radula of *A. fluviatilis* of approximately the same shell length.

Remarks. *Ancylus sp.* is characterised by the small maximum individual size, the depressed apex that is not hooked, and the fineness of the radial sculpture. Shells of similar shape are present in one sample of *A. fluviatilis* (Text-fig. 42), but these specimens reach a greater maximum size, and the apical sculpture is relatively coarse. The distribution of *Ancylus sp.* is confined to S.W. Ethiopia, and appears to be isolated from that of *A. fluviatilis*.

Distribution. *Ancylus sp.* has a scattered distribution in S.W. Ethiopia occurring in small stony streams.



FIGS. 41–44. Dorsal and lateral shell outlines drawn by camera lucida. Figs. 41–43. *Ancylus fluviatilis*. Fig. 41. River Toquor near Mekerka. Fig. 42. 222 km. S. of Asmara on Addis Ababa road. Fig. 43. 45 km. N. of Gondar on Asmara road. Fig. 44. *Ancylus ashangiensis* sp. n. from Lake Ashangi, paratypes, B.M.N.H.

FIGS. 45–47. Dorsal, lateral and posterior outlines. Fig. 45. *Ferrissia isseli* ? from 89 km. W. of Guder. Figs. 46, 47. *Ferrissia clessiniana.?* Fig. 46. 17 km. S. of Adolla. Fig. 47. 46 km. on Carsa road from junction with Dire Dawa-Harar road.

Ancylus ashangiensis sp. n.

LOCALITY. Wollo : E. shore of Lake Ashangi (14).* D. S. Brown, 6.9.62.

Shell (pl. 3, 19 and Text-fig. 44)

The outline of the base is narrow, tapering posteriorly with almost straight sides. The high and sharply pointed apex is slightly turned to the right and situated at about three-quarters of the longest dimension from the anterior margin (in 10 shells this distance varies between 0·72 and 0·86 of the total length). The tip of the shell is produced beyond the apical depression in a lip which is turned upwards so that the apical depression lies horizontally. The anterior surface is slightly convex becoming flattened towards the apex and the anterior margin ; the posterior surface is shallowly concave. Radial sculpture on the apex consists of moderately strong ribs which become less well defined peripherally and do not reach the shell margin. Circular sculpture of fine ridges is present on the apex and there are coarse irregular growth ridges elsewhere.

Holotype (B.M.N.H. coll. No. 1963920) : L = 4·8 mm. ; W = 2·3 mm. ; H = 2·2 mm.

Paratypes, B.M.N.H. and Naturhistoriska Museet, Göteborg. (Gen.-Kat. 1963–11934).

Remarks. Empty shells were abundant at the waters edge, and at distances of up to several hundred metres from the present shore. The poor development of the peripheral sculpture may in part be due to abrasion of the shells. There is variation in the relative width, but all the shells possess the distinctive sharp apex with a more or less horizontal apical depression, and a relatively narrow basal outline compared to that of *A. fluviatilis*. Of the two species of *Ancylus* previously described from Ethiopia *A. hamacenicus* Bourguignat is the narrower, but is not nearly so laterally compressed as *ashangiensis*. *A. hamacenicus* (= *compressus* Jickeli) was collected together with *A. abyssinicus* by Jickeli who acknowledged (1874, p. 223) that it might be a shell form produced by individuals living on plant stems. Both these species have been discussed above and are regarded as belonging to *A. fluviatilis*. The fact that all the Lake Ashangi specimens have the characteristic narrow shape is against the possibility that this may be merely a response to substratum, and supports the view that the populations are significantly distinct from the other forms of *Ancylus* described in this paper.

Of the *Ancylus* known from other parts of N. Africa, *A. peraudieri* Bgt. and *A. strictus* Morelet (Bourguignat, 1864) resemble *A. ashangiensis* in their basal outline but differ considerably in the shape of the apices.

DISCUSSION

The present collection contains ten forms which are either new or have not been previously recorded from Ethiopia.

Pila speciosa	*Lentorbis junodi*
Physa sp.	*Segmentorbis kanisaensis*
Bulinus ugandae	*Ferrissia isseli?*
Bulinus sp. (*truncatus* group)	*Ancylus sp.* (*fluviatilis* group)
Bulinus sp. (*forskali* group)	*Ancylus ashangiensis*

Physa sp., *Ancylus sp.* and *A. ashangiensis* may be regarded as having palaearctic origins ; the seven remaining forms belong to the African fauna.

Ethiopia lies within the North East African Province of the zoogeographical regions of Africa proposed by Pilsbry and Bequaert (1927) on the basis of the molluscan fauna. Bacci (1951) considered that the prevalence of palaearctic forms on the Ethiopian plateaux justified the distinction of an Ethiopian Sub-Province from a Somali Sub-Province. The aquatic gastropod species considered to have palaearctic relationships by Bacci are listed below together with those in the present collection :

Bacci (1951)	Present Collection
Theodoxus africanus	—
Valvata nilotica scioana	*Valvata sp.*
—	*Physa sp.*
Radix pereger	—
Galba truncatula	*Lymnaea truncatula*
Ancylus abyssinicus	
A. hamacenicus	*Ancylus fluviatilis*
—	*Ancylus sp.*

The following species are known only as empty or sub-fossil shells.

—	*Ancylus ashangiensis*
Hydrobia gortanii	—
Tropidiscus planorbis parenzani	*Planorbis planorbis parenzani*

Zoogeographical significance cannot be attached to the present record of a single population of *Physa* as a similar species occurs, probably as a result of introduction by human agency, further south in Africa. Significant additions to Bacci's list of palaearctic forms have thus been made only in the genus *Ancylus*. On the other hand, of the additional forms belonging to the African component in the fauna, four were found on the plateau : *L. junodi*, *S. kanisaensis*, *Bulinus sp.* (*forskali* group) and *Ferrissia isseli?* and three : *Pila speciosa*, *Bulinus ugandae* and *Bulinus sp.* (*truncatus* group) at lower altitudes. *Burnupia caffra* is another species of African affinities that occurs on the plateau and was not known to Bacci.

The present collection increases the number of forms of freshwater gastropod molluscs of African rather than palaearctic affinities known to occur in Ethiopia, but it may be concluded from the wide distribution of *L. truncatula* and the genera *Valvata* and *Ancylus*, together with the diversity of forms within the *Ancylus fluviatilis* species group, that these are long established representatives of the palaearctic fauna on the Ethiopian plateaux.

SUMMARY

A collection of freshwater Gastropoda comprising 28 forms, 10 of which have not been previously recorded from Ethiopia, is described.

Ancylus ashangiensis sp.n. belonging to the *Ancylus fluviatilis* species group is described.

REFERENCES

Ayad, N. 1956. Bilharziasis survey in British Somaliland, Eritrea, Ethiopia, Somalia, Sudan and Yemen. *Bull. Wld. Hlth. Org.* 14 : 1–117, 10 figs.

Azevedo, J. F. de, Medeiros, L., & Faro, M. 1957. Os moluscos de agua doce do Ultramar Portugues. 2. Moluscos do Sul do Save (Mozambique). *Estudos, Ensaios e Documentos*, 31 : 1–116, 34 pls. Ministerio do Ultramar, Lisbon.

Azevedo, J. F. de, et al. 1961. Os moluscos de agua doce do Ultramar Portugues. 3. Moluscos de Mozambique. *ibid :* 88 : 1–394, 62 pls., 62 figs.

Bacci, G. 1940. Molluschi fossile dell 'antico fondo del Lago Zwai. *Ann. Mus. Stor. nat. Genova*, 60 : 454–458, 2 figs.

—— 1943. Nuovo contributo alla conoscenza della malacofauna dell'Africa Orientale Italiana. *ibid.* 61 : 120–140, 2 figs.

—— 1951. Elementi per una malacofauna dell'Abissinia e della Somalia. *ibid.* 65 : 1–144.

Blanford, W. T. 1870. *Observations on the Geology and Zoology of Abyssinia.* London.

Bourguignat, J. R. 1864. *Malacologie de L'Algerie.* vol. 2. Paris.

—— 1883. Histoire malacologique de l'Abyssinie. *Ann. Sci. nat.* 15 : 47–162, 4 pls.

—— 1888. *Iconographie malacologique des animaux mollusques fluviatiles du lac Tanganika.* Paris.

Brown, D. S. 1961 A description of *Burnupia sp* cf *caffra* (Krauss) Gastropoda, Ancylidae) from Ethiopia. *Ann. Mag. nat. Hist. series* 13, 4 : 377–382, 6 figs.

BROWN, D. S. 1964. Observations on the distribution and ecology of freshwater gastropod Mollusca in Ethiopia. *Contributions from the Biology Department, University College, Addis Ababa* : in press.

BURCH, J. B. 1960. Chromosome Numbers of schistosome vector snails. *Z. f. Tropenmed. u. Parasit.* 11 (4), 449–452.

—— 1964. Cytological studies of Planorbidae (Gastropoda : Basommatophora). I. The African subgenus *Bulinus* s.s. *Malacologia* **1** : In Press.

CONNOLLY, M. 1928. On a collection of land and freshwater mollusca from Southern Abyssinia. *Proc. zool. Soc. Lond.* **1928** : 163–184, 1 pl., 4 figs.

—— 1939. A monographic survey of the South African non-marine Mollusca. *Ann. S. African Mus.* **33** : 1–660, 19 pls., 58 figs.

—— 1941. South Arabian non-marine Mollusca. *British Museum (N.H.) Expedition to South-West Arabia*, 1937–38, **1** : 17–42.

DEMIAN, E. S. 1962. *Anisus oasiensis* n.sp. A new planorbid species from Egypt. *Ark. Zool.* Series 2, **15** : 149–162, 9 figs.

DUNCAN, C. J. 1958. The anatomy and physiology of the reproductive system of the freshwater snail *Physa fontinalis* (L.). *Proc. zool. Soc. Lond.* **131** : 55–84, 13 figs.

GERMAIN, L. 1904. Sur quelques mollusques terrestres et fluviatile rapportes par M. Ch. Gravier du Desert Somali. *Bull. Mus. Hist. nat. Paris*, **10** : 344–359, 1 fig.

—— 1919. Sur les Limnees africaines appartenants au groupe du *Limnaea* (*Radix*) *natalensis* Krauss. *ibid.*, 179–186.

—— 1921. *Faune malacologique des Isles Mascareignes*. Angers.

GIOVANNOLA, A. 1937. Schistosomiasi intestinale da *S. mansoni* nel Harar e sua transmissione con il *Planorbis boissyi*. *Riv. Parassit.* **1** : 158–162, 1 fig.

—— 1939. Ospiti intermedi dello *Schistosoma mansoni* in Africa Orientale Italiana. *ibid.* **3** : 139–144, pls. 1, 2 figs.

HAAS, F. 1932. Die Kobeltsche Bearbeitung det vin C. V. Erlanger in N. O. Afrika gesammelten Mollusken—Berichtungen und Nachträge. *Senckenbergiana*, **14** : 173–185.

—— 1936. Binnen-mollusken aus Inner-Afrika. *Abh. senckenberg. naturf. Ges.* **431** : 1–156, 8 pls., 17 figs.

HUBENDICK, B. 1951. Recent Lymnaeidae. *Kungl. svenska veten. Handlingar*, **3** : 1–222, 5 pls., 369 figs.

—— 1958. The development of the penial stylet in *Gyraulus* (Moll. Pulm.). *Ark. Zool.* Series 2, **11** : 427–429, 4 figs.

JICKELI, C. F. 1874. Fauna der Land-und Susswasser Mollusken Nort-Ost-Afrikas. *Nova Acta Leop. Carol.*, **37** : 1–352, 11 pls.

LACAZE-DUTHIERS, H. DE. 1899. Des organes de la reproduction de l'*Ancylus fluviatilis*. *Arch. Zool. exp. Gen.*, **7** : 33–120, 44 figs.

MANDAHL-BARTH, G. 1954. The freshwater molluscs of Uganda and adjacent territories. *Ann. Mus. Afr. centr. Tervuren*, **32** : 1–206, 96 figs.

—— 1957a. Intermediate hosts of *Schistosoma*. African *Biomphalaria* and *Bulinus*. *Bull. Wld. Hlth. Org.* **16** : 1103–1163, 15 pls., 17 figs.

—— 1957b. Intermediate hosts of *Schistosoma*. African *Biomphalaria* and *Bulinus*. 2. *ibid.* **17** : 1–65, 25 pls., 8 figs.

—— 1957c. La validita di *Bulinus* (*Physopsis*) *abyssinicus* (Martens), l'ospite intermedio di *Schistosoma haematobium* in Somalia. *Accad. naz. Lincei*, series 8, **23** : 478–481, 1 pl., 1 fig.

MANDAHL-BARTH, G. 1960. Intermediate hosts of *Schistosoma* in Africa—some recent information. *Bull. Wld. Hlth. Org.* **22** : 565–573, 2 pls., 2 figs.

—— 1962. Key to the identification fo East and Central African freshwater snails of medical and veterinary importance. *ibid.* **27** : 135–150, 32 figs.

MARTENS, E. VON. 1866. Ueber einige afrikanische Binnenconchylien. *Malakozool. Bl.* **13** : 91–110, 2 pls.

—— 1867. Ueber einige Muscheln de oberen Nilgebeites. *ibid.* **14** : 17–20.

Martens, E. von. 1869. Ueber einige abyssinische Schnecken. *ibid.* **16** : 208–215.

Mohr, P. A. 1961. The geology, structure, and origin of the Bishoftu Explosion Craters. *Bull. Geophysical Observatory, University College Addis Ababa*, **2** : 65–101, 13 figs.

Morelet, A. 1872. Notice sur les coquilles terrestres et d'eau douce recueillies sur les côtes de l'Abyssinie. *Ann. Mus. Stor. nat. Genova*, **3** : 180–201.

Neuville, H. & Anthony, R. 1905. Premiere liste de mollusques d'Abyssinie (collection Maurice de Rothschild). *Bull. Mus. Hist. nat. Paris*, **2** : 115–117.

—— 1908. Recherches sur les mollusques d'Abyssinie. *Ann. Sci. nat.* 9th series, **7** : 241–340, 3 pls., 35 figs.

Pain, T. 1961. Revision of the African Ampullariidae species of the genus *Pila* Röding 1798. *Ann. Mus. Afr. centr. Tervuren*, series in 8vo, **96** : 1–25, 1 pl.

Piersanti, C. 1940. Molluschi del lago Tana e delle zone finitime. In *Missione di studio al Lago Tana*, **3** : Chimica e biologia, 233–241, 11 pls.

—— 1941. Mollusca. *Missione biologica Sagan-Omo*, **12** (6) : 263–281, 12 pls.

Pilsbry, H. A. & Bequaert, J. 1927. The aquatic molluscs of the Belgian Congo with a geographical and ecological account of Congo malacology. *Bull. Amer. Mus. nat. Hist.*, **53** (2) : 69–602, 67 pls., 93 figs.

Pollonera, C. 1888. Molluschi dello Scioa e della valle dell'Havash. *Bull. Soc. malac. ital.* **13** : 49–87.

—— 1898. Molluschi terrestri e fluviatile dell'Eritrea raccolti dal Generale Boccard. *Boll. Mus. Zool. Anat. comp. Torino*, **13** : 1–13, 1 fig.

Rochebrune, A. T. de & Germain, L. 1904. Mollusques recuellies par la Mission du Bourg de Bogas. *Mem. Soc. zool. Fr.*, 27 : 5–29.

Rohrbach, F. 1937. Oekologische und morphologische untersuchungen an *Viviparus* (*Bellamya*) *capillatus* Frauenfeld und *V.* (*B.*) *unicolor* Olivier. *Arch. Molluskenk.* **69** : 177–218, 20 figs.

Roth, J. R. 1856. Spicilegium molluscorum orientalium annis 1852 et 1853 collectorum. *Malakozool Bl.* **3** : 17–58, 2 pls.

Schutte, C. H. J. & van Eeden, J. A. 1959. Contributions to the morphology of *Biomphalaria pfeifferi* (Krauss). 2. Internal anatomy. *Ann. Mag. nat. Hist.* series 13, **2** : 136–156, 22 figs.

Slugocka, M. 1913. Recherches sur l'appareil genital des Gastéropodes pulmonés du genre *Physa*. *Rev. suisse Zool.*, **21** : 75–109, 2 pls.

Stiglingh, I., van Eeden, J. A. & Ryke, P. A. J. 1962. Contributions to the morphology of *Bulinus tropicus*. *Malacologia*, **1** : 73–114, 5 figs.

Thiele, J. 1933. Die von O. Neumann in Abissinien gesammelten und einige andere africanischen Landschnecken. *Sitz. Ges. Naturf. Freunde Berlin*, 280–323, 2 pls.

Walker, B. 1914. Notes on the Ancylidae of N. Africa. *Nautilus*, **27** : 113—117, 1 pl.

Wright, C. A. 1963a. The freshwater gastropod Mollusca of Angola. *Bull. brit. Mus. nat. Hist.* (*Zool.*), **10** : 447–528, 16 pls., 126 figs.

—— 1963b. The freshwater gastropod molluscs of Western Aden Protectorate. *ibid.* **10** : 259–274, 2 pls., 12 figs.

Wright, C. A. & Brown, D. S. 1962. On a collection of freshwater gastropod molluscs from the Ethiopian Highlands. *ibid.* 8 : 287–311, 2 pls., 32 figs.

ABBREVIATIONS USED IN FIGURES AND TEXT

an	anus	pa	papilla
ag	albumen gland	pg	preputial gland
agl	cut edge of duct within albumen gland	pm	posterior shell adductor muscle
bp	brood pouch	pn	pulmonary siphon
br	branchial ridge	PP	preputium length
cm	columellar muscle	pr	prostate
ct	ctenidium	PS	penis sheath length
dl	dorsal lamella	r	rectum
fp	fertilisation pocket	rm	retractor muscle
H	shell height	rr	lateral rectal ridge
hd	hermaphrodite duct	sv	seminal vesicle
L	shell length	t	testis
lm	left anterior shell adductor muscle	UD	umbilicus diameter
lt	left tentacle	ur	ureter
ML	aperture length	ut	uterus
mp	mantle process	va	vagina
mct	cut edge of mantle	vd	vas deferens
med	median rectal ridge	vl	ventral lamella
ov 1–3	oviducts 1–3	W	shell width
p	penis	♂	male aperture

LOCALITIES REFERRED TO IN TEXT

References are to the East African Metre Grid 1 : 500,000 G.S.G.S. 4355, and for Harar only G.S.G.S. 1401 (First Edition, 1960). It should be noted that the spelling of place names is variable, and that many old town names are being replaced by modern Amharic names.

Adamitullo	HCT 3269	Dukem	HDE 5472
Adi Ugri	HFL 4147	Filtu	JBN 9666
Adolla	HCE 6650	Ghion (Wolisso)	HDD 5344
Adowa	HFE 5166	Gondar	HEJ 9894
Agarro	HCR 0568	Gorgora	HEJ 8154
Akaki	HDE 4280	Goro Gomoto	HDE 5030 approx.
Ambo	HDD 3992	Guder	HDD 3191
Argereselam	HCL 1219	Harar	DJ 6028
Asmara	HFL 6496	Hagere Hiwot (Ambo)	
Assendabo	HCR 6656	Jimma	HCR 2748
Bahar Dar	HEC 9182	Kombolchia	HEF 4425
Batei	HEF 7037	Kombi	HDD 0804
Bishoftu (Debra Zeit)		Koka	HDE 8237
Bonga	HCP 6002	Lake Abaya (L. Margherita)	
Carsa	DJ 3045	Lake Abyata	HCT 2741
Cheren	HFT 0243	Lake Aramyia	DJ 4539
Debra Berhan	HDM 2269	Lake Ashangi	HEM 2190
Debra Markos	HDS 2442	Lake Awasa	HCL 1882
Debra Zeit	HDE 6267	Lake Biete Mengest	HDE 6469
Decamere	HFL 6669	Lake Bishoftu	HDE 6269
Dessie	HEF 3331	Lake Guder (Lake Hora)	
Dilla	HCK 9008	Lake Haik	HEF 3852
Dire Dawa	DJ 3160	Lake Hora Harsadi, or Orsedi (Lake Beite Mengest)	
Dollo	JBJ 5362		

Lake Hora	HDE 6471	Nego	HDE 7530 approx
Lake Margherita	HCK 6607	River Awash (S. of Nazareth)	HDF 0229
Lake Shala	HCT 2525	River Ganale Doria	JBJ 3384
Lake Wonji	HDD 4773	River Toquor (at Mekerka)	
Lake Zwai	HCT 4169	Saati	HFT 8825
Lekemti	HDH 9505	Shashamanne	HCL 2198
Massawa	HFU 1018	Soddu	HCK 2857
Medhanie Alem	HFD 6802	Sokuru	HCR 9173
Mekerka	HFT 3910	Teramni	HFL 4260
Moggio (Mojo)	HDE 7851	Uachile Wells	HBT 7202
Nazareth	HDE 9445	Wolisso	HDD 5344
Neghelli	HBU 3910	Wondo	HCL 0130